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A Ground Water Storage Program
For The State Water Project:
San Fernando Basin Theoretical Model

lletin 186
ay 1979

ON THE COVER: (Photo courtesy Los Angeles County Flood Control District) LOOKING NORTHEAST across the San Fernando Valley toward the San Gabriel and Verdugo Mountains. Several of the spreading grounds and flood control facilities that are used for the theoretical model are shown. In the foreground are the Branford Spreading Basin (on left) and Tujunga Spreading Grounds. In the background are Hansen Dam and Spreading Grounds.

Department of
Water Resources

Bulletin 186

A Ground Water Storage Program For The State Water Project:
San Fernando Basin Theoretical Model

May 1979

Huey D. Johnson
Secretary for Resources

Edmund G. Brown Jr.
Governor

Ronald B. Robie
Director

The Resources Agency

State of California

Department of Water Resources

CONVERSION FACTORS

English to Metric System of Measurement

Quantity	English unit	Multiply by	To get metric equivalent
Length	inches (in)	25.4	millimetres (mm)
		.0254	metres (m)
	feet (ft)	.3048	metres (m)
	miles (mi)	1.6093	kilometres (km)
Area	square inches (in^2)	6.4516×10^{-4}	square metres (m^2)
	square feet (ft^2)	.092903	square metres (m^2)
	acres	4046.9	square metres (m^2)
		.40469	hectares (ha)
		.40469	square hectometres (hm^2)
		.0040469	square kilometres (km^2)
	square miles (mi^2)	2.590	square kilometres (km^2)
Volume	gallons (gal)	3.7854	litres (l)
		.0037854	cubic metres (m^3)
	million gallons (10^6 gal)	3785.4	cubic metres (m^3)
	cubic feet (ft^3)	.028317	cubic metres (m^3)
	cubic yards (yd^3)	.76455	cubic metres (m^3)
	acre-feet (ac-ft)	1233.5	cubic metres (m^3)
		.0012335	cubic hectometres (hm^3)
		1.233×10^{-6}	cubic kilometres (km^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s)	28.317	litres per second (l/s)
		.028317	cubic metres per second (m^3/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
		6.309×10^{-5}	cubic metres per second (m^3/s)
	million gallons per day (mgd)	.043813	cubic metres per second (m^3/s)
Mass	pounds (lb)	.45359	kilograms (kg)
	tons (short, 2,000 lb)	.90718	tonne (t)
		907.18	kilograms (kg)
Power	horsepower (hp)	0.7460	kilowatts (kW)
Pressure	pounds per square inch (psi)	6894.8	pascal (Pa)
Temperature	Degrees Fahrenheit (°F)	$\frac{tF - 32}{1.8} = tC$	Degrees Celsius (°C)

FOREWORD

This bulletin describes a storage concept which, if incorporated into the State Water Project, would be the first major change in operation of that project since its inception in 1959. Under this concept, ground water basins--in effect, underground reservoirs--would be used to store a portion of the water required by the State Water Project to meet future demand.

The concept itself is not new and has been practiced in some California ground water basins since the late 1800s. California's master plan for statewide water resources--the California Water Plan of 1957--describes the conjunctive operation of ground water basins with surface water supplies as essential to the full ultimate development of the State's water resources. However, use of the underground storage space was not included as one of the original conservation facilities of the State Water Project, because of the uncertainties associated with storage rights and the possible conflicts with emerging local ground water management plans.

Since then, recent court decisions have removed some of the uncertainties and management attitudes have changed. The Department is once again looking at alternative conservation facilities that could be used to help provide the additional yield that will be needed to ensure that the State Water Project will be able to deliver, when needed, the full contracted amount of water.

A preliminary study of a large-scale storage program using ground water basins in the San Joaquin Valley and Southern California, has indicated as much as 493 cubic hectometres (400,000 acre-feet) of yield could be provided, with only minimal impact upon the environment.

Through development of a theoretical model in the San Fernando Basin of Los Angeles County, as described in this report, many of the legal, financial, institutional, physical, and environmental factors involved in such a program have been identified. Resolution of some of the problems that have appeared will be accomplished, it is hoped, through the demonstration projects now under way in the Mojave and Bunker Hill-San Timoteo Ground Water Basins of San Bernardino County.

Indeed, ground water storage deserves the thoughtful attention of all concerned citizens. I endorse the concept and pledge the continued effort of the Department toward its implementation.

Ronald B. Robie, Director
Department of Water Resources
The Resources Agency

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State of California
Department of Water Resources
CALIFORNIA WATER COMMMISSION

The California Water Commission serves as a policy advisory body to the Director of Water Resources on all California water resources matters. The nine-member commission provides a water resources forum for the people of the State, acts as liaison between legislative and executive branches of State Government, and coordinates Federal, State, and local water resources efforts.

ACKNOWLEDGMENTS

An advisory committee was established within the study area to provide special assistance during the conduct of this study. Its member agencies and participating individuals are:

City of Burbank

James D. Woodburn
Keith A. Lockwood
Samuel Gorlick

City of Glendale

Steven J. Meyerhofer
Frank R. Monzano

City of Los Angeles Department of Water and Power

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Melvin L. Blevins
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Donald D. Stark

Los Angeles County Flood Control District

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The Metropolitan Water District of Southern California

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City of San Fernando

Joseph E. Comstock
Neville R. Lewis

State of California Attorney General's Office

Edwin J. Dubiel
Emil Stipanovich, Jr.

The Department expresses appreciation for the support and cooperation of all these members during this study.

PROLOGUE: GROUND WATER STORAGE--WHAT AND WHY

In 1931, the State Water Plan was presented to the California Legislature as a means of developing the water resources to meet the needs of the State. To keep pace with the anticipated growth of the State, it was to be implemented in stages and updated as necessary.

Accordingly, the Legislature passed and the voters approved the Central Valley Project Act of 1933 to implement the initial features of the State Water Plan. However, because of the nationwide depression of the early 1930s, the authorized revenue bonds were unmarketable, and the project could not be funded.

Federal funding and authorization were later arranged, and construction of the Central Valley Project began in 1935 by the U. S. Bureau of Reclamation. By means of this project, water is stored in a number of reservoirs, and several thousand cubic hectometres are delivered throughout the Central Valley each year.

Later, the State Water Project (SWP) was authorized, as a part of the California Water Plan, by the California Legislature through the Burns-Porter Act of 1959 and ratified by the voters the next year. It provides for developing water resources in Northern California, with delivery at various points in Northern and Southern California. It too was to be implemented in stages. The design yield is 5 200 cubic hectometres (4.23 million acre-feet) per year, all of which has been contracted for by 31 water supply contractors. The annual contracted amounts are known as annual entitlements.

The 31 contractors supply about 25 percent of the State's land area, containing about 65 percent of its assessed valuation and 69 percent of its population.

As completed today, the SWP provides only about half its designated yield, or maximum annual entitlements. The demand will soon exceed the current yield.

Under the authorizing legislation, the Department of Water Resources was to augment existing SWP water supplies through such measures as the transfer of water across the Sacramento-San Joaquin Delta and construction of multiple purpose dams, reservoirs, aqueducts, and appurtenant works in Northern California watersheds.

The Department has examined a number of alternative measures for future water supplies to meet maximum annual entitlements. The alternative measures, which are discussed in Bulletin 76, "Delta Water Facilities" (July 1978), are:

1. *Increased waste water reclamation*
2. *Construction of conveyance facilities (the Peripheral Canal) in the Sacramento-San Joaquin Delta*
3. *Increased water conservation*
4. *Storage of SWP water in ground water basins in the Central Valley and Southern California, plus enlargement of the California Aqueduct, the SWP's principal facility, to transport the water needed both for storage and for annual contractor requests*
5. *Construction of reservoirs on some of the tributaries of the Sacramento River*
6. *Construction of offstream surface reservoirs in the Central Valley to store SWP water*

Each of these is being examined from the standpoint of the engineering, economic,

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legal, institutional, and environmental impacts of its components. In addition, consideration is being given to a proper mix of the components of these alternatives to ensure that the program selected is adaptable to changing conditions.

In a concurrent move, the Southern California Water Conference, an organization comprising more than 100 public officials and business leaders involved with Southern California's water supply, asked the Department of Water Resources to assist them in a study to determine if the ground water basins--many of which have storage space available--could be used for storing SWP water for later pumping and use by local water agencies.

In a phase I study conducted in 1973, the Department found the proposal to be feasible. As a result, the Southern California Water Conference recommended that a phase II study be conducted to carry out two basic undertakings:*

1. *Additional study by the Department of a long-term SWP ground water storage program to provide part of the SWP's design yield.*

2. *Negotiation on a basin-by-basin basis among the Department, SWP water contractors, and local agencies using ground water basins, with the goal of developing agreements to implement ground water storage programs in Southern California.*

These recommendations were adopted by the Department of Water Resources in 1975, and the study reported here was begun as an essential element in the examination of alternatives for augmenting the yield of the SWP.

The use of ground water basins as storage reservoirs for surface water has been practiced for a number of years by many water agencies. Water is stored in ground water basins in times of heavy runoff and later, in dry periods, is pumped and used. Basically, it is a means of meeting water demand through careful planning to make maximum use of existing resources.

The program envisioned here would coordinate the use of SWP water and facilities with local ground water basins and surface facilities. In general, this could be carried out by either one of two methods or combinations of them: (1) direct storage and extraction, as shown in Figure 1 (that is, by spreading SWP water in stream channels or spreading basins or by injecting it through special wells and then pumping it out later); and (2) indirect storage (Figure 2) by surface delivery of SWP water for direct use in areas that normally use ground water, with cessation of or decrease in amount of ground water pumped so that the basin builds up naturally until its water is pumped later (also known as the in-lieu-of-pumping method).

During periods when yield from surface supplies would be insufficient to meet all SWP annual entitlements, a portion of the SWP surface water intended for areas with stored ground water could be diverted to any water-deficient areas served by the SWP. At the same time, an equal quantity of stored ground water could be pumped from the ground water basin to replace that which had been diverted to the other SWP areas.

Water stored in the basin could also be used at times of interruption of surface deliveries, such as would occur if the California Aqueduct had a major break.

The ground water basins being considered must meet the following criteria:

- *Facilities for importing, delivering,*

*"Ground Water Storage of State Water Project Supplies", California Department of Water Resources, Southern District, District Report, June 1974.

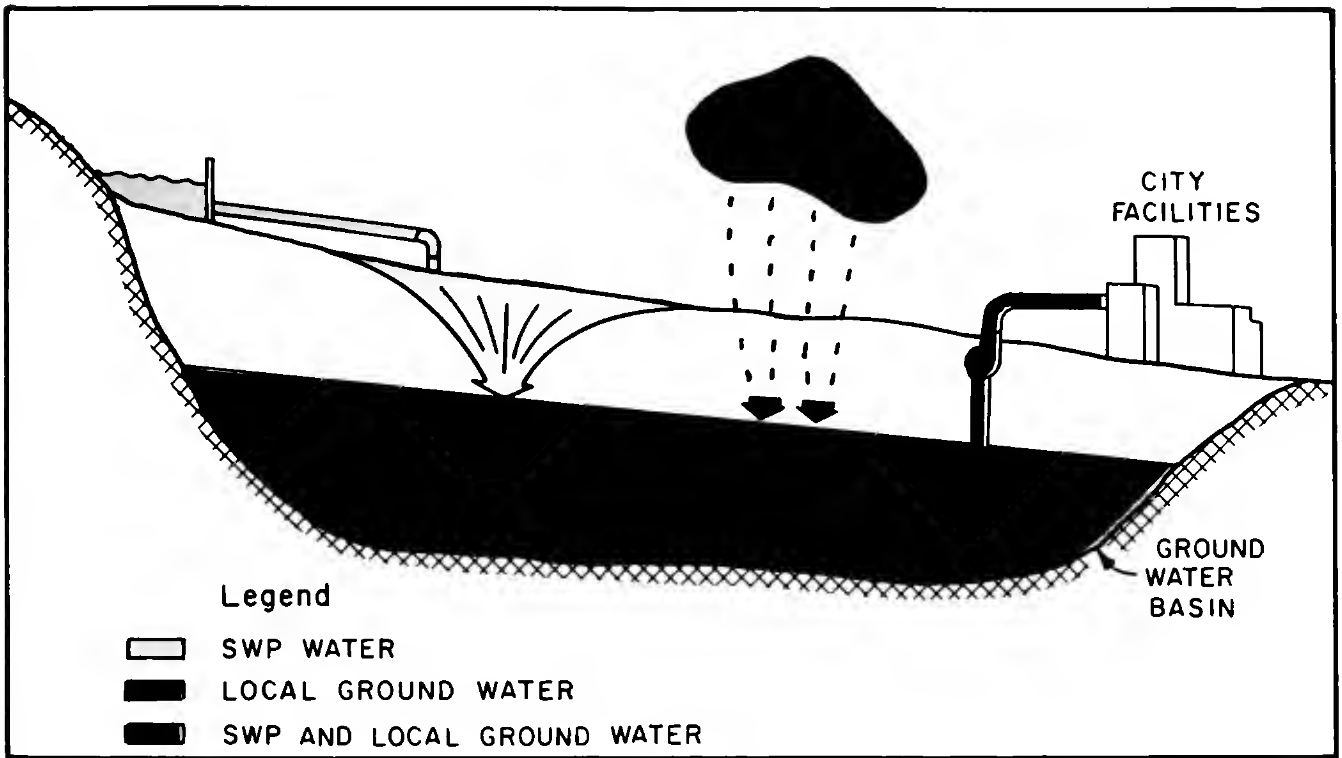

Figure 1 - SCHEMATIC OF DIRECT STORAGE METHOD

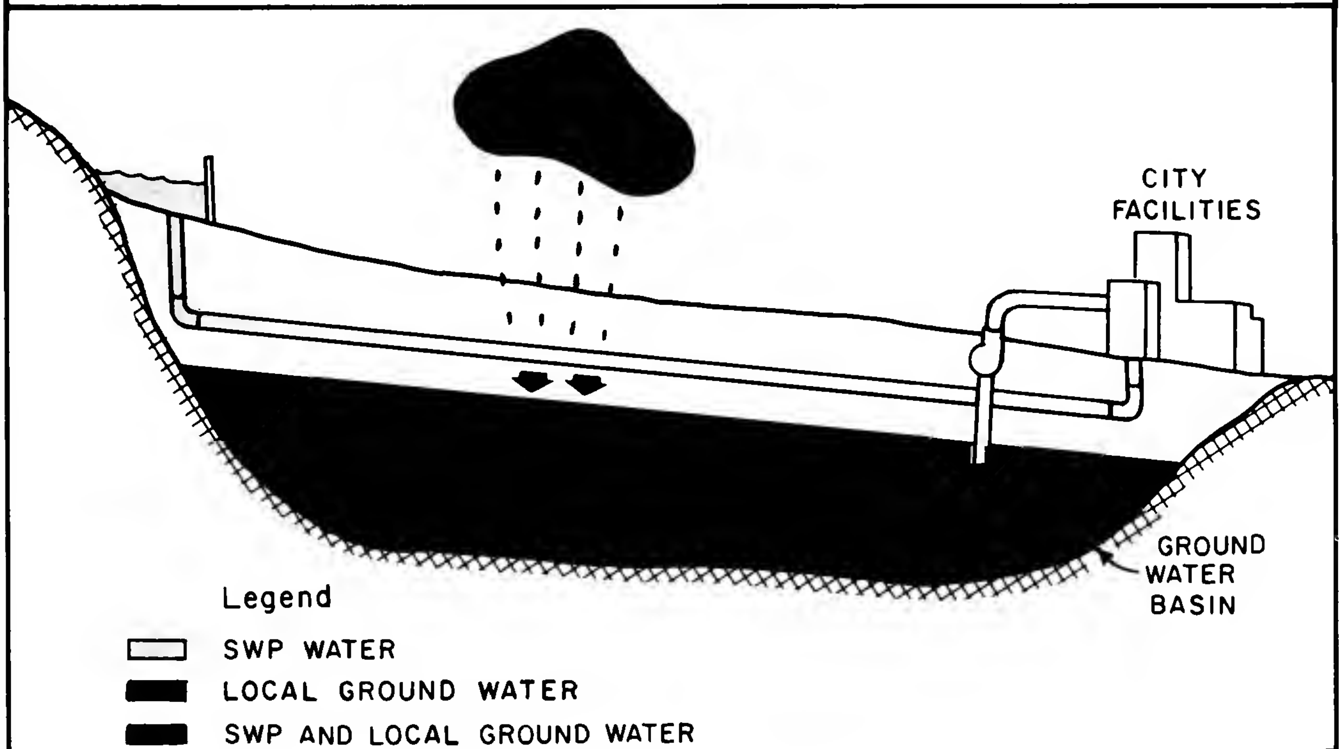

Figure 2 - SCHEMATIC OF INDIRECT STORAGE METHOD

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1978

and spreading the water are readily available, or facilities could be economically constructed,

- *Adequate storage capacity exists in the basin,*
- *The points of spreading and recapture are in hydraulic continuity,*
- *Relatively shallow wells are available or easily provided at the potential recapture sites, and*
- *No major water quality problem exists in the basin.*

CHAPTER I. INTRODUCTION

To be effective, a ground water storage program would have to be planned to satisfy economic, environmental, engineering-technical, legal, and institutional considerations and, at the same time, fit into local basin management plans.

Therefore, the Department of Water Resources recognized the need for developing a theoretical model of a ground water storage program so that the various factors to be considered in implementing such a program could be identified. To do this, an actual basin was selected and an operational schedule that was physically feasible was developed for storage and recapture of State Water Project (SWP) water.

Although the operational schedule developed for the theoretical model is considered physically possible for the basin selected, it is based on a number of assumptions. A schedule for actual storage and recapture would be based on hydrologic conditions in the Sacramento-San Joaquin Delta and in the ground water basin itself, capabilities of SWP and local facilities, and requirements of local agencies' management plans.

The next step in this program is the implementation of a demonstration project in a ground water basin, both to validate the principles developed and to test the integration of the program with SWP operations. Specifically, a number of economic, legal, and institutional problems need to be resolved.

While the Department was considering the implementation of a demonstration project, the heavy storms of early 1978 produced record quantities of water in many California watersheds. This offered the opportunity to store water for a demonstration project. Accordingly, two ground water basins in Southern California were selected and storage was undertaken.

This bulletin, therefore, includes, in addition to a report on the study behind the theoretical model, a discussion of the two demonstration projects.

Objectives of Study

The objectives of the study reported here are to:

1. Develop a theoretical model of a ground water storage program that can be integrated into local basin management plans for storing SWP water in a ground water basin for later use by SWP contractors.

2. Identify the factors--legal, financial, institutional, physical, and environmental--that must be considered before an actual ground water storage program could be implemented.

3. Resolve questions insofar as possible.

Scope and Conduct

The ground water basin selected for the theoretical model of the ground water storage program is the San Fernando Basin in Los Angeles County (Figure 3). This basin was selected largely because more is known about its geology and hydrology than any other basin in Southern California. Using the extensive data base that is available, the City of Los Angeles has developed a computer model of the basin, which has proved to be a reliable indicator of conditions in the basin. Also, the basin appeared to have the spreading grounds, pipelines, well fields, and other physical features

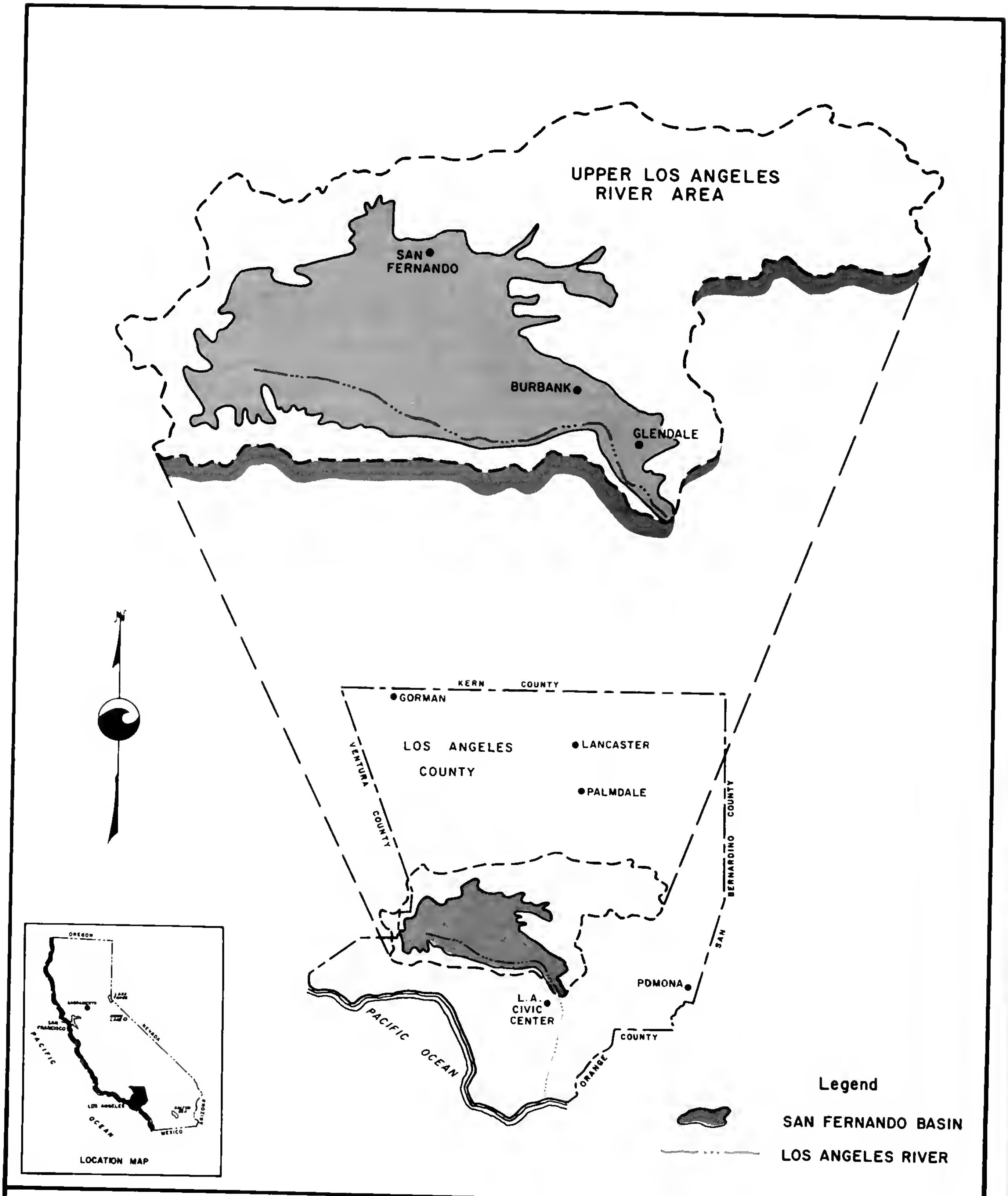

Figure 3 - LOCATION OF SAN FERNANDO GROUND WATER BASIN

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1978

SAN FERNANDO VALLEY is primarily residential, with commercial developments along major streets, such as Van Nuys Boulevard shown in the center of this picture.

that could be used, with only minor construction, to provide a workable ground water storage program. And finally, the basin is well managed, its safe yield and water rights have been identified and are nearing final resolution in adjudication, and it has been operated under court order for several years.

Involved in the study is an exploration of (1) the physical characteristics and capabilities of the basin, including the storage capacity that could be used; (2) ways to use existing conveyance, spreading, and extraction facilities at minimum cost; and (3) financial, legal, institutional, and environmental impacts involved in use of the basin.

Throughout the conduct of the study, guidance and assistance were provided by an advisory committee of engineering and legal representatives from the agencies involved in operation of the basin--The Metropolitan Water District of Southern California, the Los Angeles County Flood Control District, and the Cities of Los Angeles, Glendale, Burbank, and San Fernando. They participated in all phases of the planning process, including data collection, verification of system capabilities and basin operations, discussion of the principles to be applied in allocation of costs at State and local levels, and management of the basin.

San Fernando Basin

The San Fernando Basin underlies the Cities of Los Angeles, Burbank, Glendale, and San Fernando, all of which receive SWP water through The Metropolitan Water District of Southern California. Facilities for extracting water from the basin are operated by Los Angeles, Burbank, and Glendale; recharge facilities by Los Angeles and the Los Angeles County Flood Control District.

The basin (Figure 3) lies within the watershed of the Los Angeles River (known

as the Upper Los Angeles River Area). Overlying the basin are 45 300 hectares (112,000 acres) of the San Fernando Valley. The basin is bounded on the northeast and east by the San Gabriel Mountains, Verdugo Mountains, and San Rafael Hills, on the south by the Santa Monica Mountains, and on the west and northwest by the Simi Hills and Santa Susana Mountains. In the Santa Susana and San Gabriel Mountains, elevations range up to about 1 200 metres (4,000 feet).

The valley floor slopes toward the Santa Monica Mountains and drains into several significant washes and numerous small ones, most of which eventually join to form the Los Angeles River. The river follows a meandering, southeasterly course through the basin.

Much of the present-day structure of the valley is the result of compressive forces that have thrust the mountain ranges along the northern margin of the valley up and over the valley floor. Movement has been along north-dipping reverse or thrust-fault systems such as the Sierra Madre and Santa Susana. These fault zones trend west and northwest along the southern margins of hills and mountains north of the valley. Several inactive faults, such as the Granada Hills, Mission Hills, Verdugo, Northridge, and Chatsworth, have also been identified in the northern portion of the valley.

The predominately east-west-trending hills and mountains bordering the valley have provided alluvial deposits of more than 300 metres (1,000 feet) in depth. The basin has been infilled by coalescing alluvial fans composed of sand, gravel, silt, clay, cobbles, and boulders.

The San Fernando Valley is influenced by both desert and coastal climates. Its 10-year average annual maximum temperature is 24.4°C. (76°F.) and average annual minimum temperature is 8.9°C. (48°F.).

The average annual rainfall is approximately 410 millimetres (16 inches) on the valley floor, increasing to approximately 530 millimetres (21 inches) in the mountains. Rainfall was below normal during the water years 1969-70* through 1976-77, with the exception of 1972-73. The normal rainy season usually lasts from November through March. There is little or no rainfall during the rest of the year.

The San Fernando Valley is essentially a suburban area with almost two-thirds of all land space occupied by residences. Population in the San Fernando Valley in 1977 was almost 1.4 million.

Although approximately 65 percent of the housing units are single-family residences, the percentage of apartments and multi-family units has increased rapidly during the last decade.

Commercial development uses only 5 percent of the total land area and is mainly in strips along major highways and nodes at intersections of primary streets. Industry occupies only slightly more land than commercial development.

Transportation, utilities, and public services use 8 percent of valley land. Recreation and open space lands total about 7 percent. About 8 percent of the land space is vacant, while agriculture uses only 2 percent of the valley floor.**

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*Water year is from October 1 through September 30.

**These percentages are taken from "Coastal Los Angeles County Land-Use Study, 1973", prepared by the Southern District of the California Department of Water Resources as a District Report, April 1975.

CHAPTER II. FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary of Findings

The following findings were made in this study:

1. Estimated total capacity of the San Fernando Ground Water Basin is 3 952 cubic hectometres (3.2 million acre-feet). In 1974, the estimated amount of water in storage was 3 334 cubic hectometres (2.7 million acre-feet), leaving 618 cubic hectometres (500,000 acre-feet) as available storage space. Because the basin is in active use by the overlying cities, the amount of this space that could be used for SWP storage is limited. The exact amount that would be available has yet to be determined. Applying the criteria established by the engineering members of the advisory committee, 394.7 cubic hectometres (320,000 acre-feet) was chosen as the amount to be stored under the theoretical model developed in this study.

2. Storing 394.7 cubic hectometres of water in the San Fernando Basin and extracting it within the limits of the "7-year dry period" for which the SWP is designed* would provide a dry-period yield for the SWP of 59.2 cubic hectometres (48,000 acre-feet) per year for the life of the program.

3. In the initial years of the operational schedule for the theoretical model, SWP water supplies, conveyance capacity, and power are adequate to bring water to Castaic Lake, terminus of the West Branch of the California Aqueduct, for both the model and scheduled entitlement deliveries. Some water may also be available for surplus deliveries during the early stages of the theoretical model, but these amounts would diminish in the early 1980s. As entitlement requests increase, existing facilities will prove inadequate to convey the water required for this model. Nonetheless, for this study, the assumption was made that water, conveyance capacity, and power would be sufficient for the theoretical model throughout the operational schedule. Not explored was the effect that operation of ground water storage in a number of basins would have upon the SWP once full entitlement deliveries have been reached.

4. All SWP water comes into the San Fernando Basin via facilities of The Metropolitan Water District of Southern California (MWD). These facilities are adequate to transmit SWP water from Castaic Lake to the basin for the theoretical model, in addition to that for scheduled entitlement deliveries. However, MWD's facilities are not connected to existing spreading grounds.

5. The recharge facilities and some of the pumping facilities needed for implementing a SWP ground water storage program are already operating in the basin. They are primarily in the eastern portion where water is of better quality than that in the western portion and where the sediments more readily yield water to wells.

6. Statutory authority for construction of the SWP and its necessary conservation facilities is contained in the Burns-Porter Act (California Water Code Section 12930). In addition, under two recent decisions (<u>The City of Los Angeles</u> v. <u>City of</u>

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*The SWP is designed to meet its contractual commitments even with a drought such as that experienced in the 7 years of 1928–34.

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San Fernando and Niles Sand and Gravel Company, Inc. v. Alameda County Water District), the courts have recognized that public agencies have the right to:

- o Store water in a ground water basin;
- o Protect the stored water from expropriation; and
- o Recapture the stored water.

7. Two different methods of storing water and combinations of them are practical for use in the San Fernando Basin. These are (a) direct storage (artificially recharging the basin) and (b) indirect storage (reducing extractions and using surface-delivered water instead).

8. The stored ground water--which would be considered SWP ground water, no matter how stored--would be recaptured by the cities now pumping from the basin. They would pump and chlorinate SWP ground water, using it in place of an equal amount of imported treated water that would have been delivered on the surface by MWD. The participants have other options for recapturing the SWP ground water (exchange of water rights or extraction and delivery to other participants) that are physically possible, but the Los Angeles City Charter prohibits the exchange of the city's water or water rights. This would reduce the amount of water that could be stored and recaptured each year.

9. With the use of existing facilities and a limited amount of additional construction, approximately 80 percent of the total amount of SWP water to be stored in the basin could be directly stored and the rest indirectly stored; in the management plan for the theoretical model, this was designated as storage combination 1. At the other extreme, about 65 percent of the total could be indirectly stored and the rest directly stored with even less additional construction; this is combination 2.

10. For the indirect portion of both combinations, existing facilities would be adequate. For the direct storage portion, existing spreading grounds are adequate, but connectors would have to be built to get water from MWD facilities to the spreading grounds. Five different connectors appear possible.

11. Under operation of storage combination 1, the 394.7 cubic hectometres (320,000 acre-feet) of SWP water could all be stored over a 6-year span and recaptured in a subsequent 5-year period. If a second cycle is used, storage could be accomplished in 5 years and recapture in 5 years. Combination 2 would require 7 years for the initial storage, 5 years for recapture, 6 years for the second storage cycle, and 5 years for recapture.

12. The most economical route for direct storage requires the construction of a connection from the terminus of the San Fernando Tunnel to Pacoima Wash channel (Figure 4). This would take SWP water to Lopez and Pacoima Spreading Grounds for recharging the basin and would be sufficient for combination 2 (primarily indirect storage). If additional spreading proved necessary, as for combination 1 (primarily direct storage), a second route would have to be used.

13. Under the management plan for the theoretical model, operation would be supervised by an operating committee with overall responsibility to all parties involved. The State would initiate requests for storage and recapture and the operating committee would determine if the requests could be complied with. However, to ensure a firm yield for the SWP, the operating committee

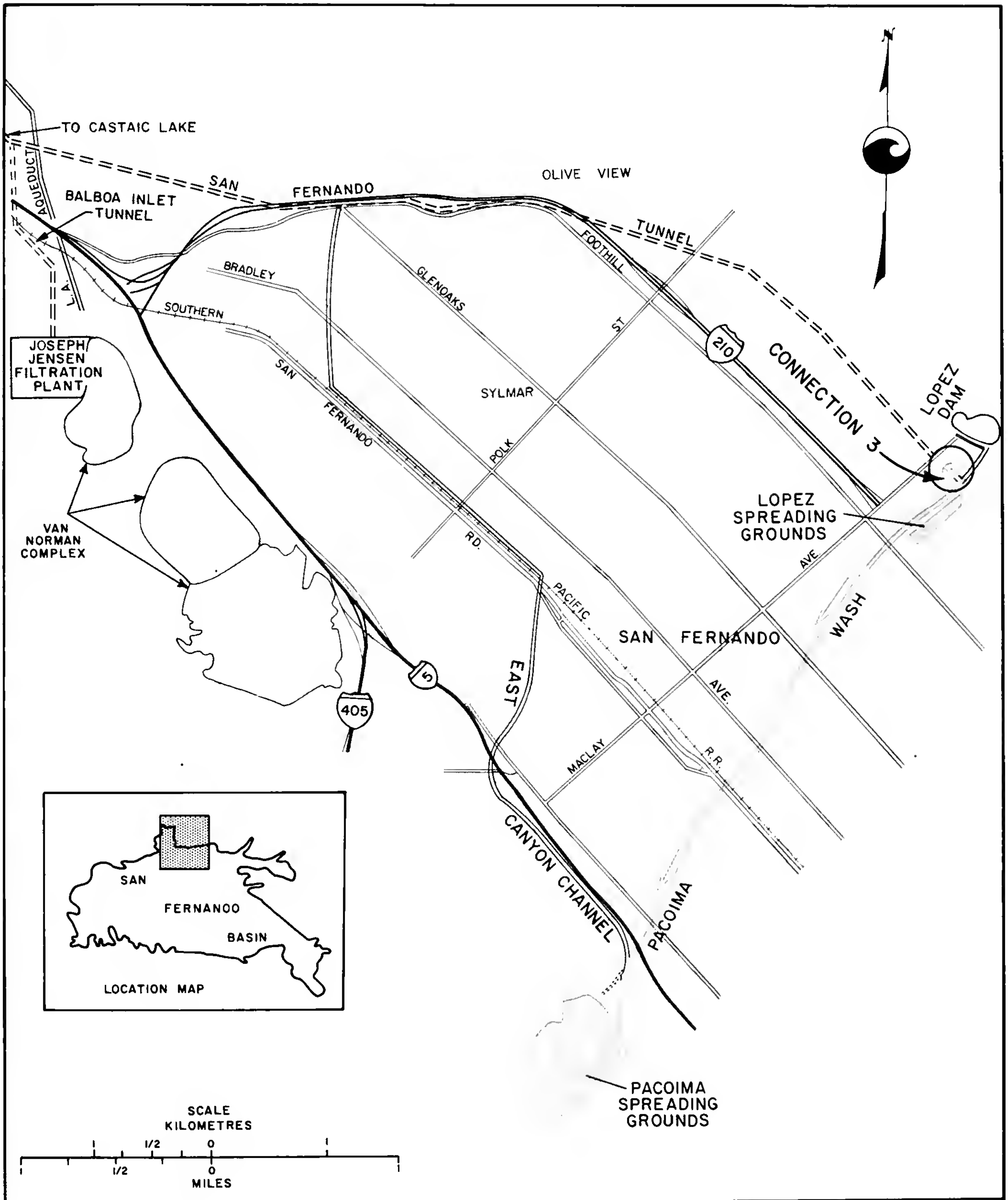

Figure 4 - MOST ECONOMICAL ROUTE FOR DIRECT STORAGE

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1978

TABLE 1
ALLOCATION OF COSTS AND SAVINGS FOR OPERATION OF THEORETICAL MODEL
In millions of dollars

	State		MWD*	Cities	
	Combination 1	Combination 2	Combinations 1 and 2	Combination 1	Combination 2
Cost	37.4**	33.4**	0	0	0
Savings	0	0	0	1.6	3.8
Saving due to higher ground water table	0	0	0	2.1	2.1

*The theoretical model would benefit MWD and all 31 SWP water service contractors by decreasing a possible SWP shortage in water-deficient years by the amount of its yield.

**This cost will be reduced by the transportation variable payments for pumping from the Delta made by MWD during the recapture period -- estimated to be $26.4 million -- even though these costs would not actually be incurred.

could not reduce the annual amounts below the guaranteed annual minimum that each participant had agreed to store or recapture, unless an emergency arose.

14. Protection of rights of each participant to water in the basin would require supervision by a court-appointed administrator (watermaster).

15. Although an analysis can be made of the incremental cost of the model in the San Fernando Basin (i.e., the cost beyond that which would be incurred without the ground water storage program), a complete cost analysis of concurrent operation of a series of SWP ground water storage programs, as is being contemplated in the SWP future supply studies, cannot be made at this time. It requires that a determination be made of the additional facilities needed to transport SWP water for both maximum entitlement deliveries and all SWP water storage programs. This additional cost may be substantial.

16. For the economic analysis of the theoretical model, the assumption was made that ground water storage would be classified as an additional SWP conservation facility and that repayment provisions of existing water supply contracts would be used. Therefore, reimbursement to the State would be through the Delta Water Charge. The allocation of costs and savings for operation of the model is shown in Table 1.

17. The rate used to compute the Delta Water Charge would be recalculated to reflect the incremental cost for this storage plus a credit of $26.4 million paid by MWD during recapture. Thus the effect upon the SWP water contractors of the incremental cost during the short-term schedule for the theoretical model would be, for combination 1, an increase in the rate of 6¢ per 1 233 cubic metres ✓ (1 acre-foot) and, for combination 2, an increase of 1¢. The increase ✓ would be for the life of the SWP (to year 2035), but the yield is only increased during the operational schedule (1976-98).

18. Because storing SWP water in the San Fernando Basin is being considered as one of the alternatives for developing future supplies for the SWP, a limited evaluation was made of the effect of operation of the theoretical model for the remainder of the repayment period of the SWP (1979-2035). Allocation of the extended operation costs and savings,

and of the savings the cities will realize from a higher ground water table, is shown in Table 2.

19. In recalculating the rate to be used for the Delta Water Charge during the extended schedule, the incremental cost allocation for the storage would be used plus the credit of $62 million paid by MWD during recapture. The resultant increase in the rate for 1979 through 2035 would be 16¢ per 1 233 cubic metres (1 acre-foot) for combination 1 and 10¢ per 1 233 cubic metres for combination 2.

20. The ground water storage program could be financed from funds available for construction and operation of the State Water Resources Development System. The SWP would be reimbursed through the Delta Water Charge for costs incurred.

21. Environmental impacts that would be expected to result from the ground water storage and the mitigation measures that would be taken are:

    - Construction. During construction of spreading and recapture facilities, the heavy equipment required could add air pollution, noise, and traffic congestion. Some of the alternative routes being considered for conveying water to the spreading grounds for storage would require construction along existing roadways, thus interfering with the normal flow of traffic.

      Controls written into the construction specifications would minimize air pollution, noise, and traffic congestion.

    - Spreading. Objectionable odors could be created if water is ponded for long periods during the summer when algae growth is apt to take place. Spreading large amounts of water could also mean possible exposure of children and pets to water-related hazards. The presence of water in the spreading grounds could also add to the propagation of mosquitoes and midges, to the attraction of water-oriented birds, and to the growth of vegetation around the perimeter of the ponds.

      The spreading grounds proposed for use are owned and operated by the Los Angeles County Flood

TABLE 2
ALLOCATION OF COSTS AND SAVINGS FOR THE LONG-TERM OPERATION, 1979 - 2035
In millions of dollars

	State		MWD*	Cities	
	Combination 1	Combination 2	Combinations 1 and 2	Combination 1	Combination 2
Cost	94.7**	88.2**	0	0	0
Savings	0	0	0	3.0	7.2
Saving due to higher ground water table	0	0	0	9.3	9.3

*The theoretical model would benefit MWD and all 31 SWP water service contractors by decreasing a possible SWP shortage in water-deficient years by the amount of its yield.
**This cost will be reduced by the transportation variable payments for pumping from the Delta made by MWD during the recapture period -- estimated to be $62 million -- even though these costs would not actually be incurred.

RECHARGE WATER entering a basin in one of the spreading grounds in the San Fernando Basin.

Control District and the City of Los Angeles. Both limit the ponding to a time shorter than that required for insect eggs to hatch and for algae to grow. They control vegetative growth by mowing, by disking and scraping the top of the soil, and by occasional applications of weedicides. Adequate fencing is provided around all the spreading grounds.

- Water in Storage. The total dissolved solids concentration of water now in the basin is 400 to 500 milligrams per litre (mg/l); that of the SWP water is less than 250 mg/l. Therefore, recharging with SWP water can be expected to have a favorable effect upon the quality in the basin. Conversely, the water now in the basin could reduce the quality of the SWP water stored.

  If the SWP water is stored too quickly and in too large amounts, the ground water table could be raised high enough to inundate completed sanitary landfills and thus cause local water quality problems.

  Too high water tables could also lead to property damage.

  On the other hand, rising water levels could tend to hold back the poor quality water in the fringe areas of the basin so that it does not move into the main body of water.

  The management plan for the theoretical model calls for establishment of an operating committee for the basin, which would be responsible for testing each phase of operation on a computer model of the basin before it is carried out, for selecting and monitoring key wells to check on water levels and quality, and for stopping operations if indications of possible damage are noted.

- Energy. The net energy use for combination 1 (primarily direct storage) would be 27 040 million

megajoules (25,620 billion British thermal units, or BTUs); that for combination 2 (primarily indirect storage) would be 25 520 million megajoules (24,170 billion BTUs). These energy quantities were calculated at the primary level, which means that a determination has been made of the total natural resources that must be used to produce the amount of energy needed at the level of use. Virtually all the energy used would be for pumping, either from the Delta to Castaic Lake or from the ground water basin.

When compared with the net energy used for normal surface deliveries, combination 1 would require 8 percent more energy and combination 2, 2 percent more.

Therefore, the net energy required for operation of a ground water storage program could be reduced by storing as much SWP water as possible by the indirect method and by retaining the SWP water in the San Fernando Basin as long as reasonable (i.e., until needed to meet water requests) and replenishing after the recapture period.*

Conclusions

From the above findings, the following conclusions can be drawn:

1. The San Fernando Basin could be used to store SWP water as one of the components of the program developed to augment the supply of water for the SWP. Use of this basin would increase the overall dry-period yield of the SWP between 1976 and 1998 by as much as 59.2 cubic hectometres (48,000 acre-feet) per year if the theoretical model were implemented. If the amount stored in the San Fernando Basin were greater or less than the 394.7 cubic hectometres (320,000 acre-feet) of the theoretical model, the yield would increase or decrease proportionately.

2. Careful scheduling would be required to minimize power costs and the conflict between surplus water deliveries and those for ground water storage over use of conveyance facilities and SWP water supplies.

3. In general, provision for use of a combination of direct and indirect storage would increase the flexibility of any ground water storage program and ensure storage of the water within a reasonable period of time. If an actual program were carried out in the San Fernando Basin, it would probably be a modification of the two combinations tested in the theoretical model.

4. Before a ground water storage program could be carried out in any basin, formal agreements would have to be entered into by the State and the participating agencies to set forth the methods, procedures, and responsibilities for delivering, storing, and recapturing SWP water and for making repayments. To ensure the yield of a ground water storage program, the participating local agencies would have to agree to guarantee a minimum storage capacity within the basin, to store the water within a reasonable period of time. and to have the capability to recapture the water within the limits of the "7-year dry period". In the case of the San Fernando Basin, two agreements would be required under the management plan: one between the State and MWD and a second one

*The theoretical model does not follow these criteria; it looks at a purely hypothetical storage and recapture schedule to test various effects on the basin and the SWP.

that would include the local member agencies of MWD.

5. If as much as 394.7 cubic hectometres of SWP water were stored in the San Fernando Basin, the charter of the City of Los Angeles would have to be amended to allow the city to participate in the exchange of water required for storage and recapture operations.

6. In the San Fernando Basin, a storage program that used primarily indirect storage would be more economical and would use less energy than a program that relied more heavily on direct storage. Therefore, the cost to the SWP contractors would be less under a program of primarily indirect storage. This would be true only when the cities and the State share the savings in ground water pumping, as was done for the theoretical model. At the same time, the local participating agencies would realize a greater savings under such a program.

7. Because operation of the theoretical model in the San Fernando Basin would increase the yield of the SWP, it would benefit all 31 SWP water supply contractors.

8. The SWP ground water storage program could be carried out without additional legislation.

9. If SWP water were used to recharge the San Fernando Basin, it would raise ground water levels, tend to reverse the flow of low quality water from the western part of the basin toward the well fields, and help to keep the low quality water in the fringe areas of the basin.

10. The local environmental impact of operation of a ground water storage program in the San Fernando Valley would not be significant. However, any change in operating the basin might also have an effect upon the various localities from which water is imported. An assessment of the effect upon these areas was beyond the scope of this study.

Recommendations

On the basis of the above findings and conclusions, the Department of Water Resources recommends that:

1. A ground water storage demonstration project, using a combination of direct and indirect storage, be instituted in the San Fernando Basin to validate the principles developed in this study and to test the integration of the ground water storage program with SWP operations.

2. The scheduling of deliveries of SWP water for the demonstration project be planned to minimize power costs and conflicts with deliveries of surplus water.

3. For direct storage of the SWP water, a single connector be built as an initial step. This connector (connection 3 in Figure 5) would deliver SWP water from the terminus of the San Fernando Tunnel to Pacoima Wash channel, which would deliver it to Lopez and Pacoima Spreading Grounds. If additional direct storage is deemed necessary, a second connector (connection 1A in Figure 5) could be built between Pacoima Wash channel and a storm drain that would take water to Branford channel and Branford Spreading Basin and to Tujunga Wash channel and Tujunga Spreading Grounds.

4. In implementing the demonstration project, indirect storage of the SWP water be used as much as possible.

5. The City of Los Angeles amend its charter to permit it to exchange water. (Until this can be accomplished Los Angeles cannot

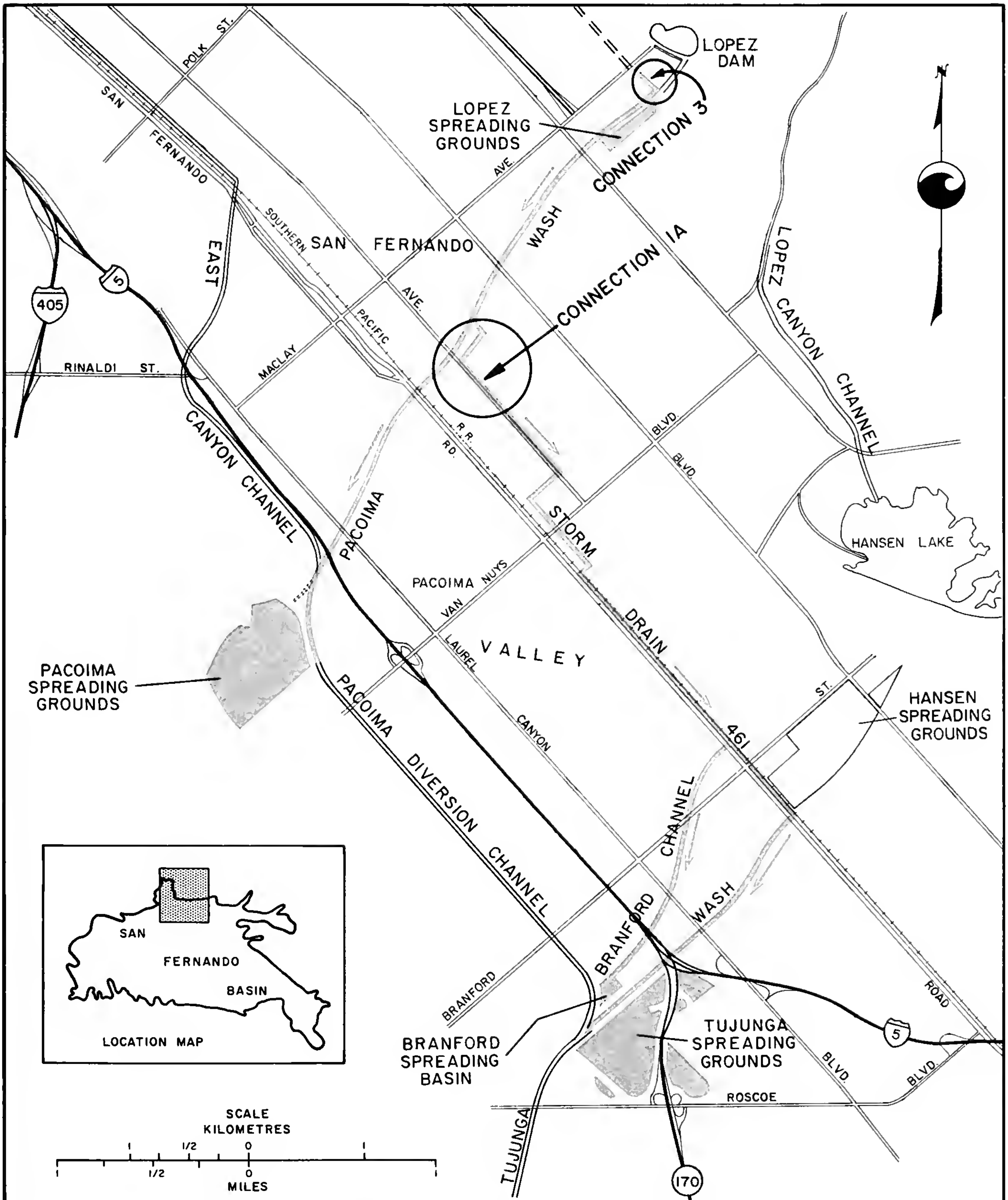

Figure 5 - RECOMMENDED ROUTE FOR DIRECT STORAGE

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1978

participate in indirect storage; also recapture could only be achieved by the cities pumping SWP ground water, chlorinating it, and using it in place of an equal amount of water that would be delivered on the surface by MWD.)

6. An agreement or agreements be drawn up and signed by the participants to govern operation of the demonstration project. These should be designed to supplement MWD's existing contract with the State. Participants would be the Department, MWD, and the local agencies involved. The provisions of the agreement or agreements should include:

   - Allocation of costs and payments among the participants;
   - Guarantee of the use of MWD and local facilities for storing and recapturing SWP water in a reasonable period of time;
   - Designation of a guaranteed volume of storage in the basin for the program;
   - Development of a method for allocating losses of the stored water in the basin;
   - Designation of a watermaster or other administrative agency for the program;
   - Establishment of guidelines for the administrative agency;
   - Assignment to the State of the right to determine when to store and recapture SWP water;
   - Protection of water rights and facilities of all the participants.

7. Environmental documents for the demonstration project be prepared.

8. If operation of the demonstration project proves satisfactory to all parties, the San Fernando Ground Water Basin be designated as an additional conservation facility of the SWP.

CHAPTER III. SURVEY OF RESOURCES

The first requirement for developing a theoretical model for a ground water storage program in the San Fernando Ground Water Basin is to ascertain the resources that are available--conveyance, recharge, storage, and extraction facilities and SWP water. The ground water basin is itself part of the storage and delivery facilities.

Ground Water Basin

The San Fernando Basin is one of the four separate ground water basins comprising the Upper Los Angeles River Area (ULARA). The other basins are the Sylmar, Verdugo, and Eagle Rock Basins (Figure 6). Basin boundaries are the result of physiographic and/or geologic features. Since 1968 all four basins in ULARA have been under the administration of the court, and the amount pumped from the basins has been designated by the court.

In 1975, the California State Supreme Court issued its decision in The City of Los Angeles v. City of San Fernando (14 Cal. 3d 199) confirming that the City of Los Angeles has the right to the native water in the San Fernando Basin and the return flows* from water the city imports. It limited the Cities of Burbank, Glendale, and San Fernando to pumping only the return flows from the water they import to the San Fernando Basin. The City of San Fernando is not at present exercising its rights to pump water from this basin, and the other two cities are adjusting their pumping from the San Fernando Basin accordingly. The decision made no change in water rights held in the other three basins within ULARA.

Deposits in Basin

The alluvial sediments, or valley fill, in the San Fernando Basin are a heterogeneous mixture of clays, silts,

OVERVIEW of the Los Angeles River Narrows just upstream from gaging station F-57C.

*Return flows normally result from the deep percolation of water applied to lawns, ornamental plants, and other vegetation.

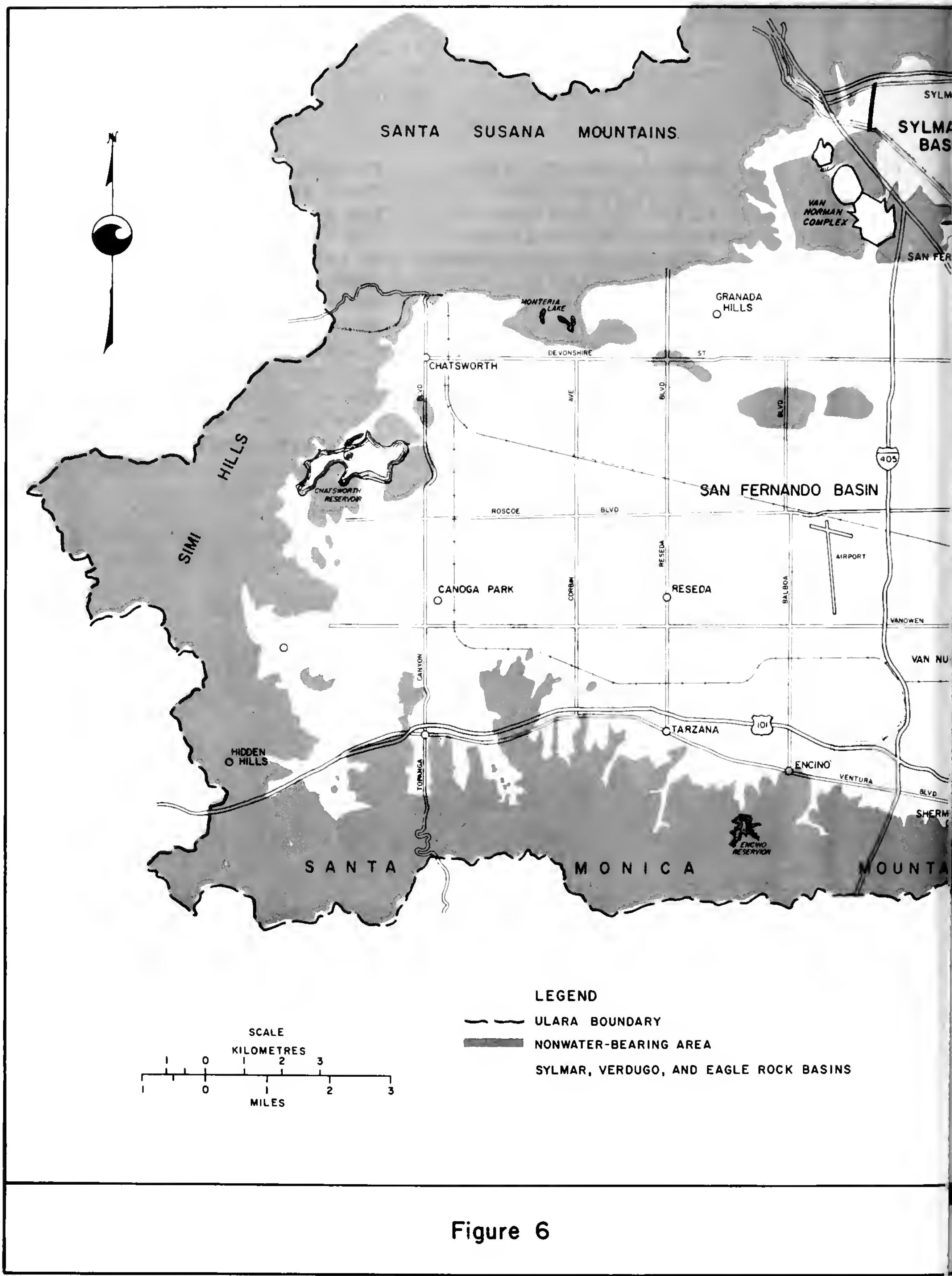

Figure 6

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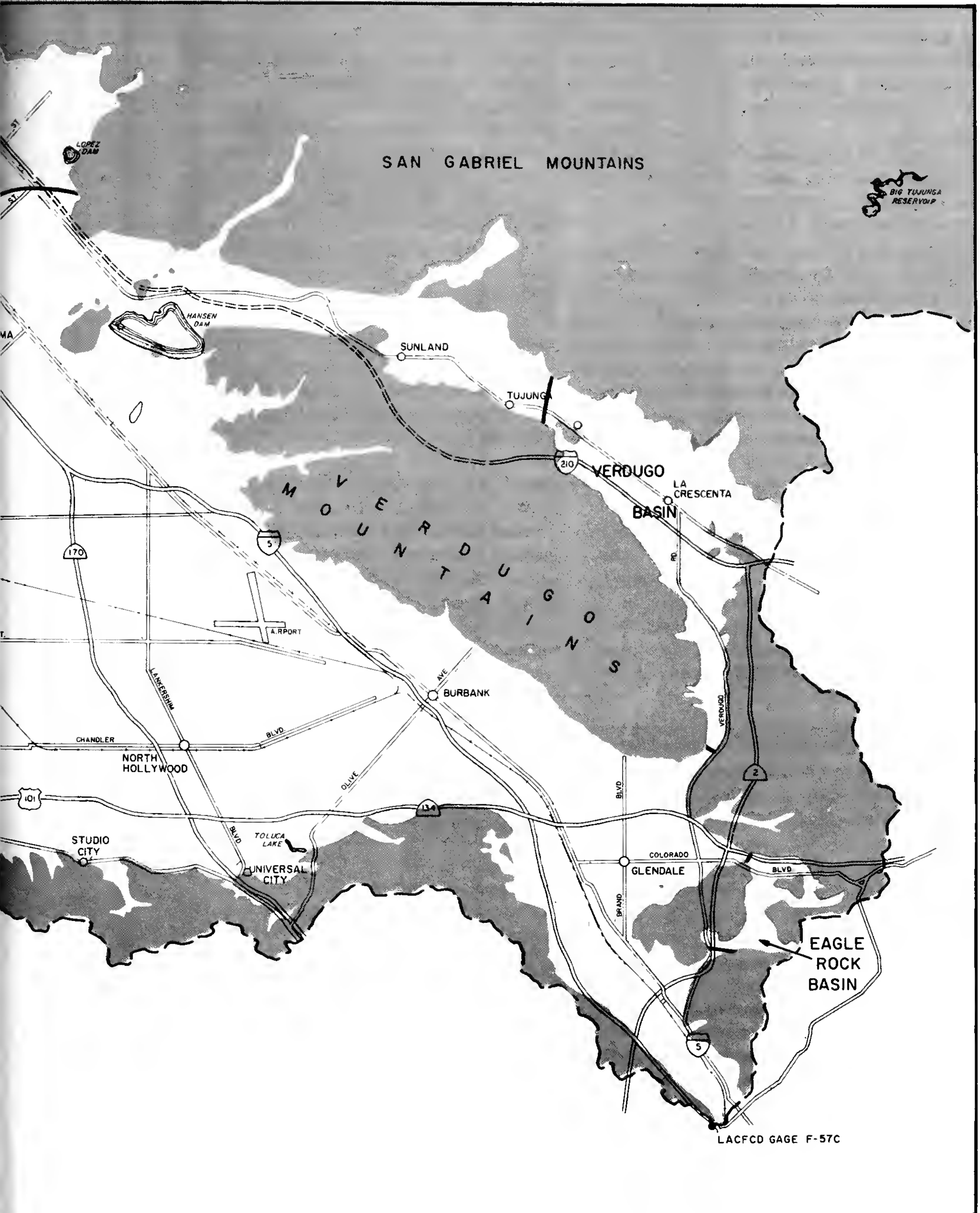


FOUR GROUND WATER BASINS WITHIN ULARA

sands, and gravels. Specific yields, or water-yielding capacities, of these materials vary from 3 percent for clay to 26 percent for coarse sand or fine gravel.

The western half of the San Fernando Basin has a high clay content and is essentially fine-grained material derived from the surrounding sedimentary rocks. This portion of the basin has high ground water levels and poor quality water. To prevent damage to surrounding properties from the high water table, the City of Los Angeles periodically pumps water from its wells in Reseda and allows it to flow into the Los Angeles River. A portion percolates into the ground water basin through the riverbed; some is captured further downstream and spread.

The east side of the basin consists of coarse sand and gravel deposits derived from the granitic basement complex of the San Gabriel Mountains. These deposits transmit water at a faster rate than do those in the west, and they constitute about two-thirds of the basin's storage capacity of 3 952 cubic hectometres (3.2 million acre-feet).

Ground water in the basin moves east or southeast on its way to the Los Angeles River Narrows (Figure 7).

At points along the river where the underlying sediments are such that the water table is near the surface, rising water appears in the river channel. In most cases, it percolates downstream or is spread in spreading grounds. However, that which appears at the Los Angeles River Narrows flows out of the basin.

Pumping

Safe yield for the San Fernando Basin is 112 cubic hectometres (90,680 acre-feet) per year.

Most of the wells are in the eastern part of the basin, because of the high water-yielding sands and gravels, the relatively rapid rate of transmission and the abundance of ground water in that area.

About 63 percent of the pumped ground water is exported from the basin by the Cities of Los Angeles and Glendale for

HANSEN DAM releases storm flows into Tujunga Wash channel. Water can be diverted from the channel by means of a diversion structure (center) into Hansen Spreading Grounds (on the left). Water can also flow further down the channel and be diverted into Tujunga Spreading Grounds.

LARGEST of the spreading grounds in the San Fernando Basin is Tujunga, shown in the foreground. Just beyond the many basins that form the spreading grounds is Tujunga Wash channel. The single basin on the other side of the channel is Branford, which is the smallest of the recharge facilities in the San Fernando Basin. On the far side of Branford is Pacoima Diversion channel. Photo is looking toward the northwest.

use in other portions of their water service areas.

As a result of the heavy pumping, water levels have changed, as have the hydraulic gradients and the direction of ground water movement within the area itself. Large depressions, or pumping holes, have been created (Figure 7). The largest of these is at the confluence of the Verdugo Wash and the Los Angeles River, caused by pumping in the Crystal Springs well field by the City of Los Angeles and in the Grandview wells by the City of Glendale (Figure 8). A second depression, in the Los Angeles River Narrows, is created by heavy pumping in the Pollock well field by the City of Los Angeles, which has resulted in a reversal of the ground water gradient.

Recharge

The primary sources of recharge for the ground water basin are direct percolation of precipitation; deep percolation along surface drainage channels; deep percolation of water applied to lawns, ornamental plants, and other vegetation; and artificial recharge by spreading of controlled runoff (including water from the Reseda wells) and imported water.

On the average, the water delivered for use by residents in the area overlying the San Fernando Basin is derived from local ground water (including water from Sylmar Basin), 15 percent; Mono Basin-Owens River water delivered by the City of Los Angeles through the Los Angeles Aqueducts, 76 percent; Northern California water delivered by the State through the SWP and facilities of The Metropolitan Water District of Southern California (MWD), 8 percent; and Colorado River water delivered by MWD through the Colorado River Aqueduct, 1 percent.

Percolation of storm runoff and rising water is a minor source of supply to users in the basin. Most of the treated domestic waste water is being exported from the basin, but a small amount is now being applied to cemeteries, parks, and golf courses. The application of reclaimed water may be increased in the future. Industrial waste waters are discharged into the channels leading to the Los Angeles River, where some percolates and some is captured and spread.

Quantity and Quality of Water

The 1974 estimate of stored ground water is 3 334 cubic hectometres (2.7 million acre-feet). With an estimated storage capacity of 3 952 cubic hectometres

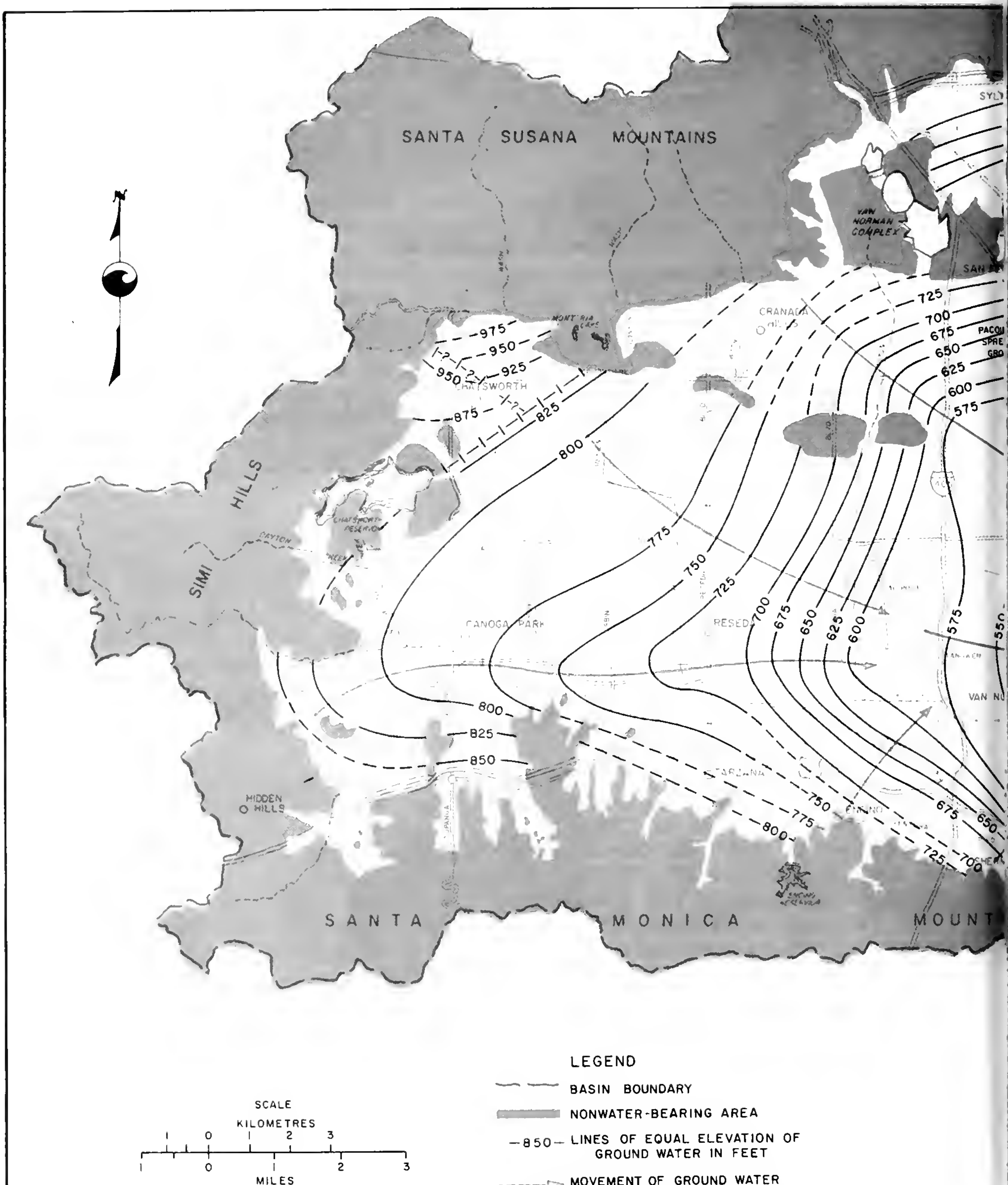
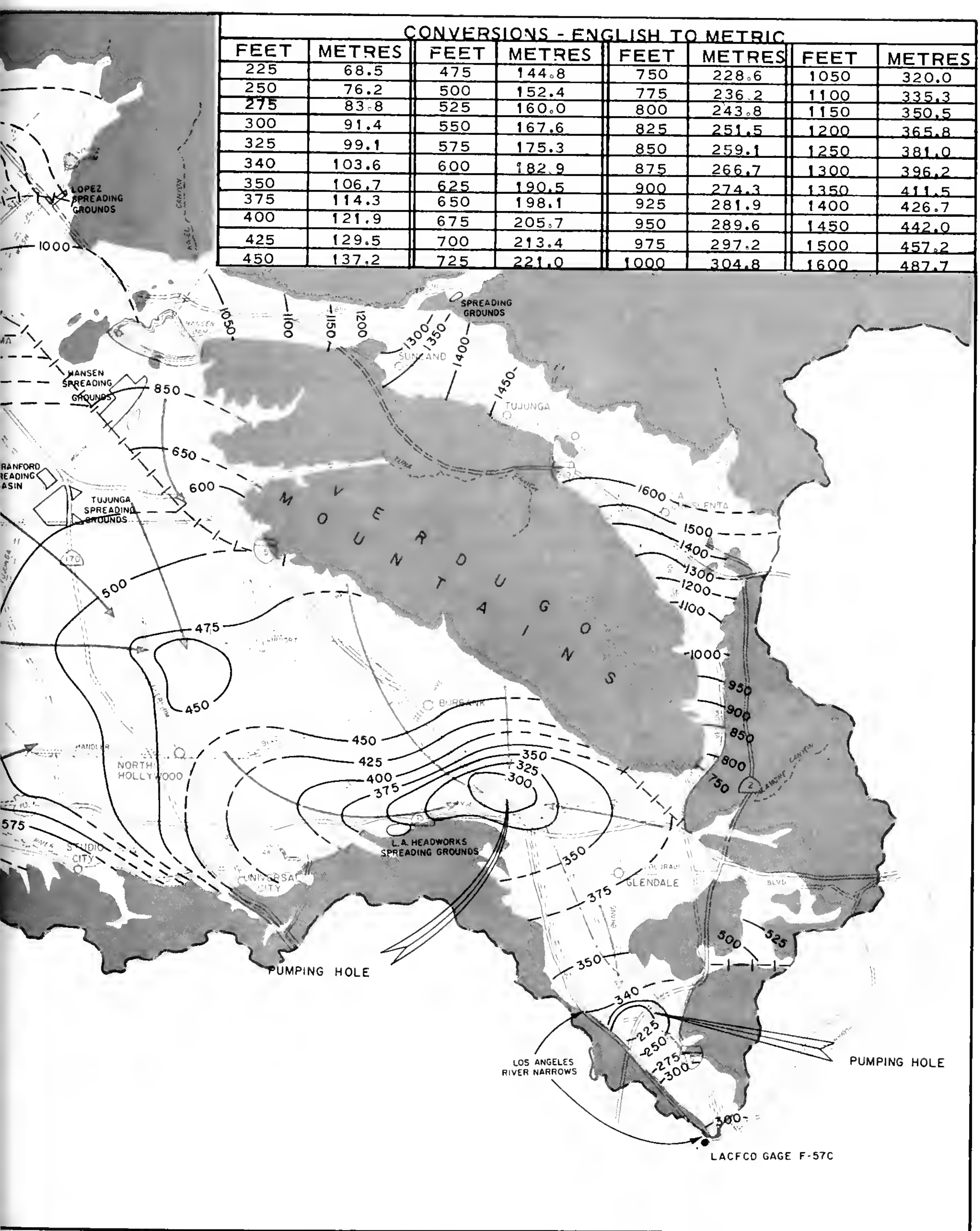


Figure 7

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1978

CONVERSIONS - ENGLISH TO METRIC							
FEET	METRES	FEET	METRES	FEET	METRES	FEET	METRES
225	68.5	475	144.8	750	228.6	1050	320.0
250	76.2	500	152.4	775	236.2	1100	335.3
275	83.8	525	160.0	800	243.8	1150	350.5
300	91.4	550	167.6	825	251.5	1200	365.8
325	99.1	575	175.3	850	259.1	1250	381.0
340	103.6	600	182.9	875	266.7	1300	396.2
350	106.7	625	190.5	900	274.3	1350	411.5
375	114.3	650	198.1	925	281.9	1400	426.7
400	121.9	675	205.7	950	289.6	1450	442.0
425	129.5	700	213.4	975	297.2	1500	457.2
450	137.2	725	221.0	1000	304.8	1600	487.7



LINES OF EQUAL ELEVATION OF GROUND WATER AND DIRECTION OF FLOW – FALL 1977

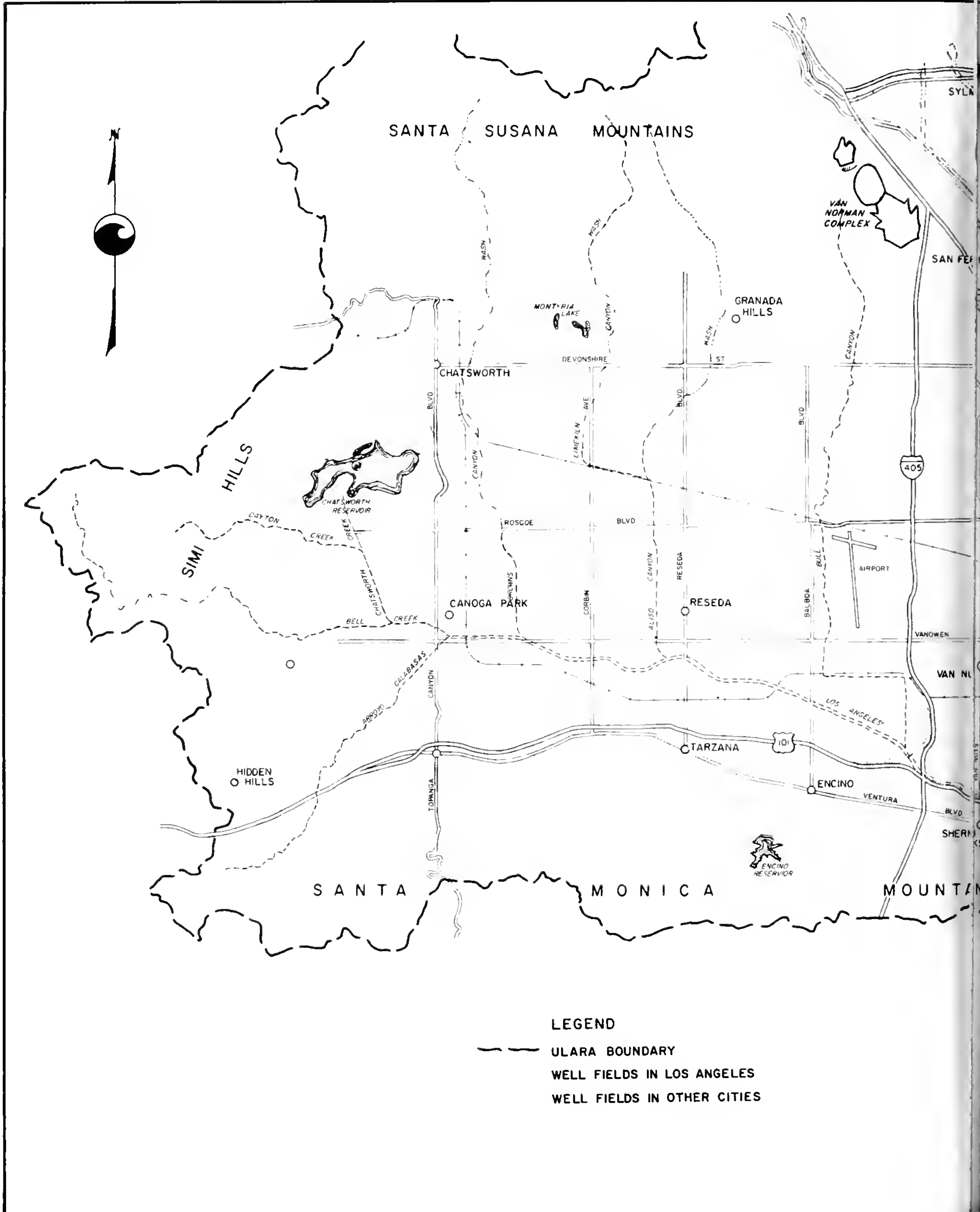


Figure 8

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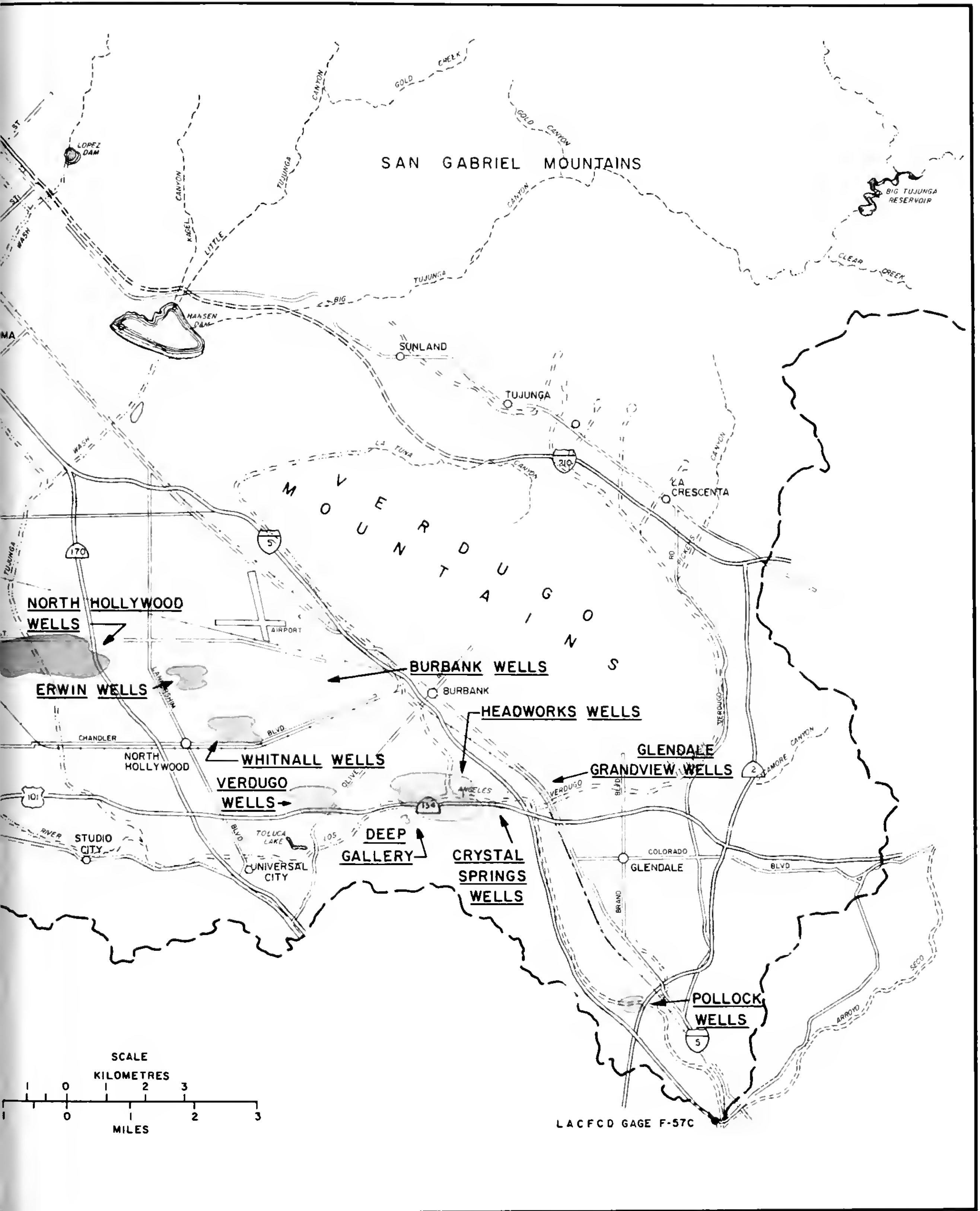


LOCATIONS OF WELL FIELDS
IN SAN FERNANDO BASIN

(3.2 million acre-feet) in the basin, the available storage space is computed to be approximately 618 cubic hectometres (500,000 acre-feet). The cities holding rights to the basin require a certain proportion for their own use, but have not yet determined how much; therefore, the exact amount that would be available for SWP storage has yet to be set.

Water in the western portion of the basin is calcium sulfate in character; in the eastern portion it is calcium bicarbonate. Both are generally acceptable according to the Interim Primary Drinking Water Regulations of the Environmental Protection Agency, but ground water in the western portion occasionally exceeds the limits for concentrations of sulfate. The water is hard to very hard* (Table 3). Figures 9 and 10 give a graphic comparison of selected constituents in water used in the basin.

Local Facilities

A survey was made of the facilities that are now being used by the various participating agencies. The Los Angeles County Flood Control District (LACFCD) and the City of Los Angeles operate spreading grounds for recharging the San Fernando Basin. The Cities of Los Angeles, Burbank, and Glendale have wells for extracting water from the basin. MWD and the Cities of Los Angeles, Burbank, Glendale, and San Fernando have surface conveyance facilities for bringing in water or distributing it.

The LACFCD spreading grounds have been used only for spreading local runoff; however, by agreement with the City of Los Angeles, they could also be used for spreading imported water from the Los Angeles Aqueducts. The spreading grounds of the City of Los Angeles are used for recharging local runoff, plus water from the Los Angeles Aqueducts and discharge from wells at Reseda. During 1975-76, 18 cubic hectometres (14,630 acre-feet) of local and imported water was spread in the basin.

The average pumping lift in the basin is 91 metres (300 feet). To pump 1 233 cubic metres (1 acre-foot) of water out of the basin requires an average of 600 kilowatthours (kWh).

Los Angeles County Flood Control District

Pacoima, Tujunga Wash, and Lopez Canyon channels, constructed by the U. S. Army Corps of Engineers, are operated and maintained by LACFCD (Figure 11). These concrete-lined channels, which start in the foothills of the San Gabriel Mountains, have been used to convey runoff from Pacoima, Tujunga, and Lopez Canyons either to the Los Angeles River or to Lopez, Pacoima, and Hansen Spreading Grounds. These spreading grounds, plus the Branford Spreading Basin, are also operated by LACFCD.

All the spreading grounds are fenced to prevent pets and children from entering. Vegetation at all the spreading grounds is controlled by mowing and the occasional application of weedicides.

All the spreading grounds, except Branford, are designed to be operated by a battery method for long duration spreading. Under this method, alternate basins are filled and, anywhere from 4 to 10 days later, percolation is completed. Next, the basins are allowed to dry for approximately two weeks, which inhibits insect infestation, algae growth, aquatic weed growth, and disagreeable odors and restores the original infiltration rate.

To handle heavy runoff, the grounds may be operated at full capacity for a short duration. This is usually during the winter when insects are not a problem.

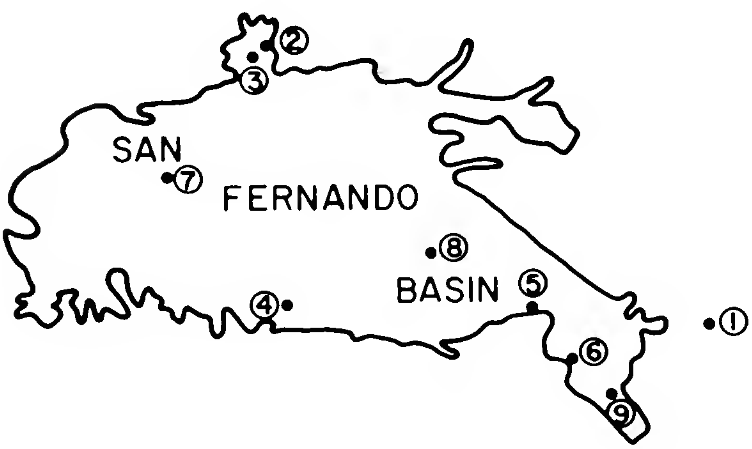
Location of the spreading grounds is shown in Figure 11; information on capacities is given in Table 4.

*Total hardness expressed as milligrams per litre of calcium carbonate ($CaCO_3$) of 150 to 300 is considered to be "hard"; all above that is "very hard".

TABLE 3
REPRESENTATIVE MINERAL ANALYSES OF WATER

	Well number or source	Date sampled	$EC \times 10^6$ at 25°C	pH	Mineral constituents in milligrams per litre (mg/l) / milliequivalents per litre (me/l): CA	Mg	Na	K	CO_3	HCO_3	SD_4	Cl	NO_3	F	8	Total dissolved solids mg/l	Total hardness as $CaCO_3$ mg/l
	IMPORTED WATERS																
1	Blended State Water Project and Colorado River Water at Eagle Rock Reservoir	1976-77 (average)	873	8.07	58 / 2.90	23 / 1.89	86 / 3.74	3.5 / 0.09	0.8 / 0.03	133 / 2.17	197 / 4.10	83 / 2.34	1.9 / 0.03	0.24 / 0.01	0.16 / 0.01	529	240
2	Owens River water at Upper Van Norman Reservoir inlet	1976-77 (average)	333	8.23	26 / 1.30	5.5 / 0.45	35 / 1.52	3.4 / 0.09	1.2 / 0.04	139 / 2.28	21 / 2.29	16 / 0.45	0.7 / 0.01	0.56 / 0.03	0.05 / 0.005	200	86
3	State Water Project water at Joseph Jensen Filtration Plant (effluent)	1976-77 (average)	494	8.32	36 / 1.80	14.29 / 1.17	42.3 / 1.84	2.3 / 0.06	1.4 / 0.05	114 / 1.37	71 / 1.48	51 / 1.43	0.48 / 0.008	0.18 / 0.009	0.21 / *	287	148
	SURFACE WATER																
4	Los Angeles River at Sepulveda Blvd.	11-3-76	1,030	9.40	82 / 4.10	33 / 2.71	44 / 4.09	6.4 / 0.16	21.1 / 0.70	171 / 2.80	238 / 4.96	91 / 2.57	27 / 0.04	* / *	* / *	728	340
		4-6-77	1,240	9.34	74 / 3.70	41 / 3.37	132 / 5.74	8.3 / 0.23	16.0 / 0.27	74 / 1.21	357 / 7.44	132 / 3.72	2.8 / 0.05	* / *	* / *	910	352
5	Los Angeles River at Burbank-Western Wash	11-3-76	846	7.72	34 / 1.70	14 / 1.15	92 / 4.00	9.2 / 0.24	0.4 / 0.01	168 / 2.75	112 / 2.33	91 / 2.57	7.0 / 0.11	* / *	* / *	408	140
		4-6-77	1,680	8.10	80 / 4.00	29 / 2.39	168 / 7.30	22 / 0.56	2.6 / 0.04	207 / 3.40	352 / 7.33	148 / 4.17	3.9 / 0.05	* / *	* / *	970	320
6	Los Angeles River at Colorado Street	11-3-76	1,010	9.13	77 / 3.85	26 / 2.14	92 / 4.00	6.8 / 0.17	18.6 / 0.31	140 / 2.29	230 / 4.79	99 / 2.79	17 / 0.27	* / *	* / *	692	300
		4-6-77	1,540	8.19	104 / 5.20	38 / 3.13	180 / 7.83	19 / 0.49	2.9 / 0.05	190 / 3.11	433 / 9.02	165 / 4.65	7.2 / 0.12	* / *	* / *	1 140	416
	GROUND WATERS (Western Portion)																
7	2N/16W-27F02 (Reseda No. 8)	11-4-76	960	7.41	119 / 5.95	31 / 2.55	44 / 1.91	1.6 / 0.04	0.8 / 0.01	310 / 5.09	200 / 4.17	30 / 0.85	33 / 0.53	0.25 / 0.01	0.30 / 0.03	605	425
	(Eastern Portion)																
8	1N/14W-08801 (North Hollywood No. 19)	6-16-77	602	7.61	70 / 3.50	19 / 1.56	29 / 1.26	3.1 / 0.08	0.9 / 0.15	225 / 3.69	89 / 1.85	19 / 0.54	19 / 0.31	0.54 / 0.03	0.10 / 0.01	379	252
	(Los Angeles River Narrows)																
9	1S/13W-04L03 (Pollock No. 6)	6-6-77	1,140	7.28	107 / 5.35	41 / 3.37	78 / 3.39	2.8 / 0.07	0.60 / 0.01	317 / 5.19	193 / 4.02	95 / 2 68	7.5 / 0.12	0.30 / 0.02	0.29 / 0.03	718	434

*Not available



NUMBERS ON MAP CORRESPOND TO THOSE ON TABLE 3 AND FIGURES 9 AND 10

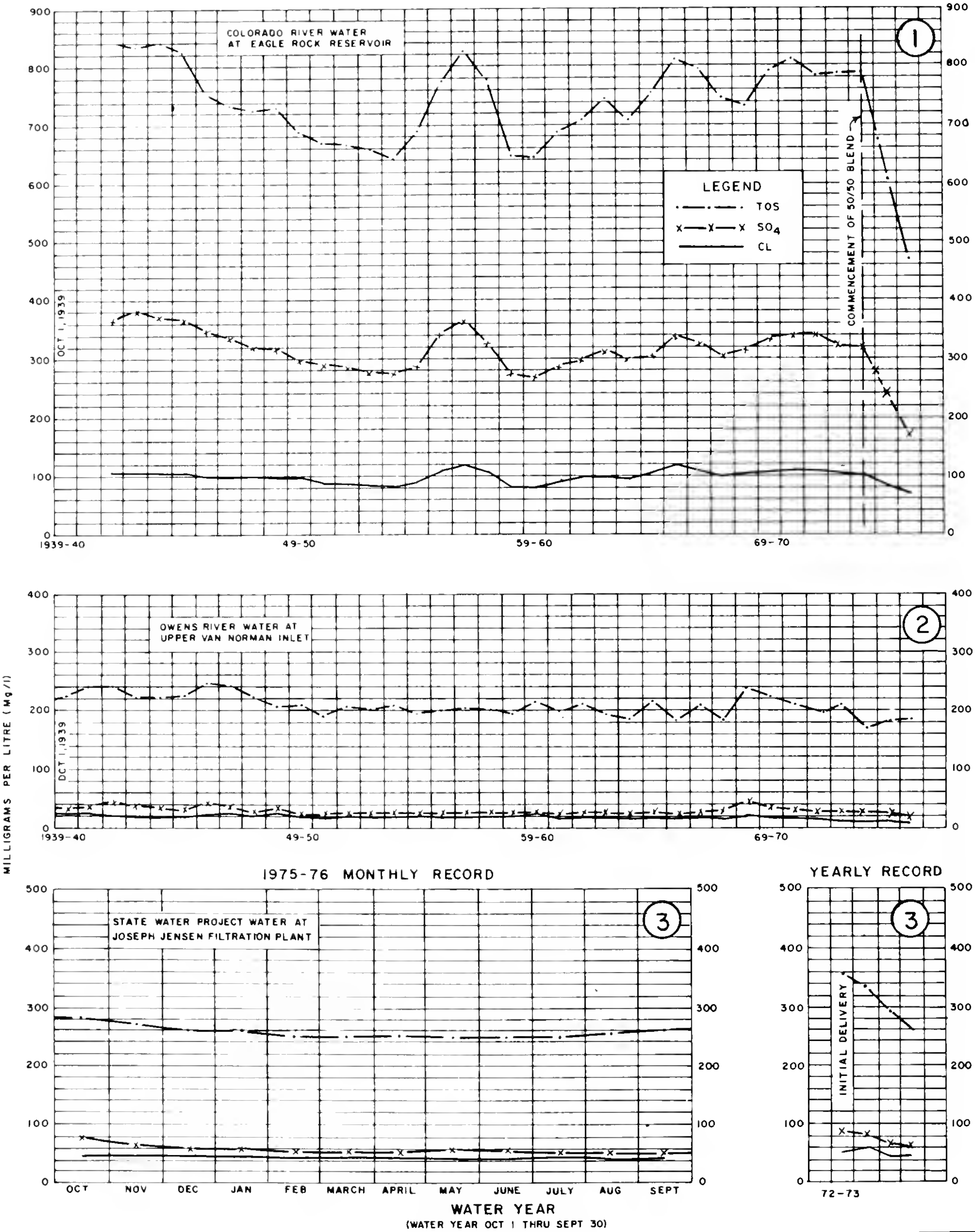


Figure 9 - TOTAL DISSOLVED SOLIDS, SULFATE, AND CHLORIDE OF IMPORTED WATER

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1978

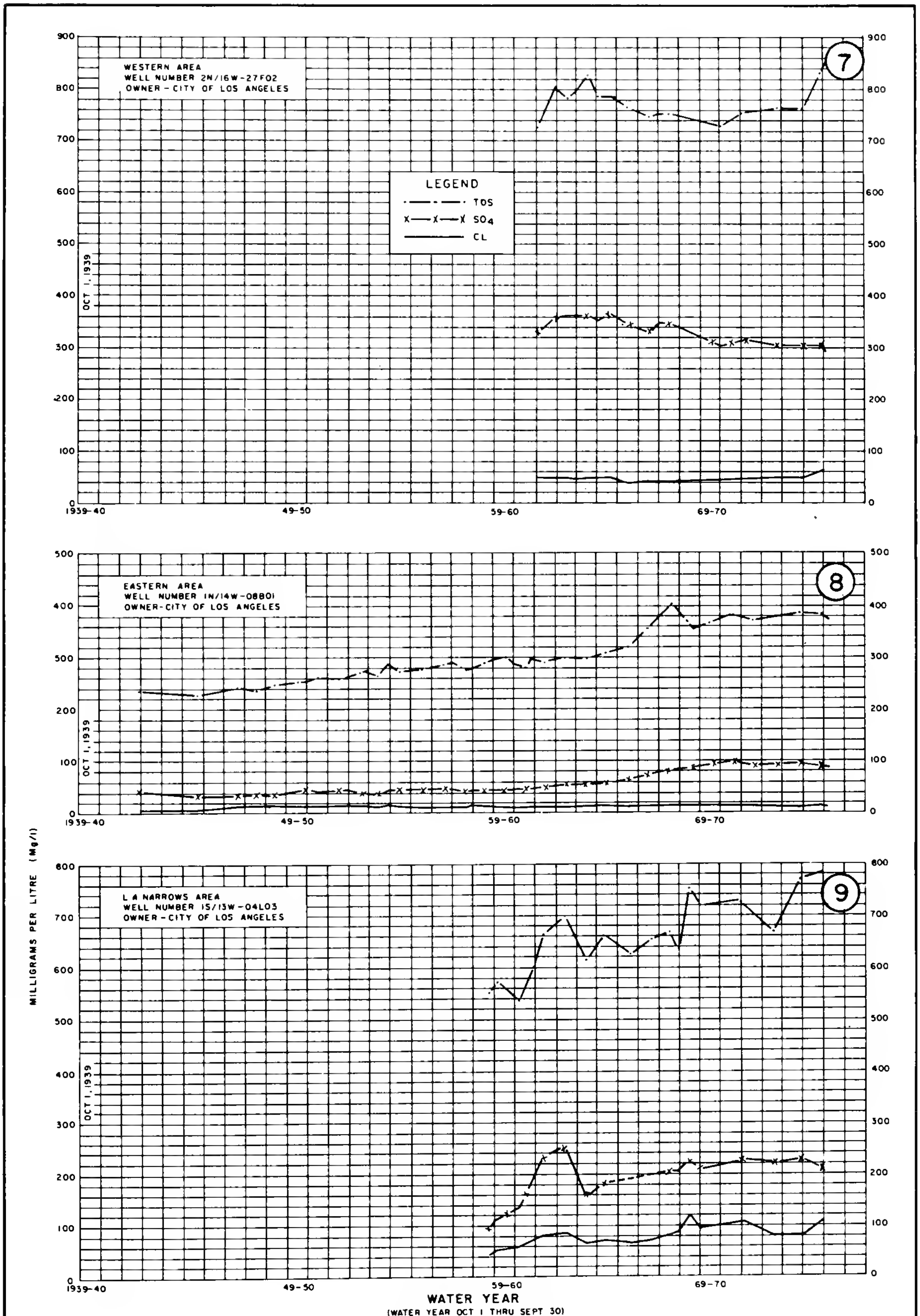


Figure 10 - TOTAL DISSOLVED SOLIDS, SULFATE, AND CHLORIDE OF GROUND WATER

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1978

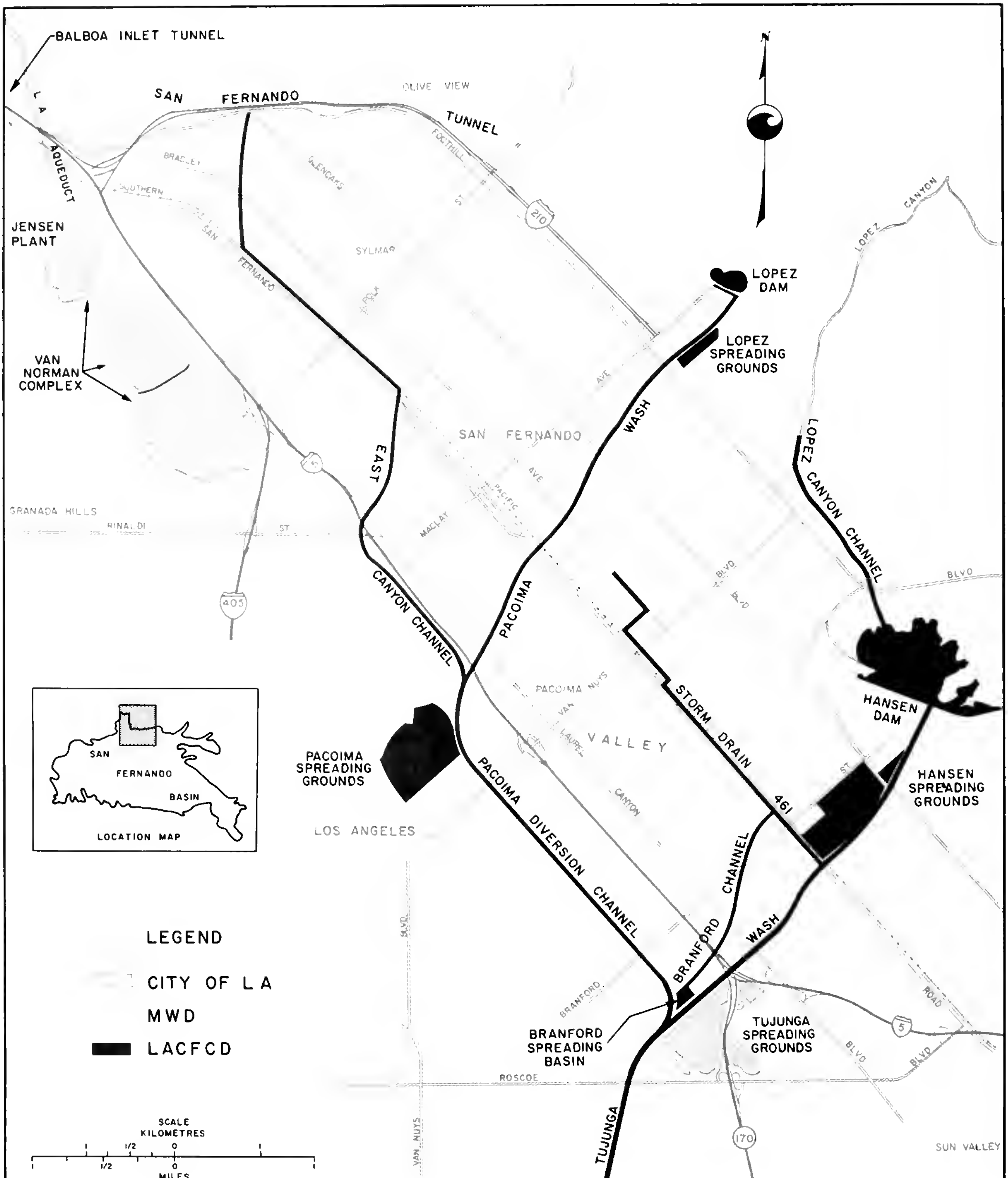


Figure 11 – LOCAL FACILITIES IN NORTHEAST SAN FERNANDO VALLEY

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1978

To date, all water spread at Lopez Spreading Grounds has been local runoff from a 98-square-kilometre (38-square-mile) drainage area.

The Pacoima Spreading Grounds are just below the confluence of the Pacoima Wash and East Canyon channel. All water spread at Pacoima has been local runoff from the same drainage area as that supplying Lopez, plus an additional 21 square kilometres (8 square miles) of highly developed residential and commercial areas below the Lopez Flood Control Basin.

Hansen Spreading Grounds are used to spread releases of controlled flow from Hansen Dam and Big Tujunga Dam, which is northeast of Hansen Dam.

Branford Spreading Basin is upstream of the confluence of Tujunga Wash and Pacoima Diversion Channel. All the water spread has been uncontrolled flow from a storm drain in a highly developed residential and commercial area.

City of Los Angeles

The City of Los Angeles depends on a complex water system to meet its annual water demand of 740 cubic hectometres (600,000 acre-feet). At present, more than 625,000 services are metered.

TABLE 4
SPREADING GROUNDS IN SAN FERNANDO BASIN

Spreading grounds	Total area In hectares		Basins		Average depth In metres		Maximum capacity		Infiltration rate In cubic metres per second	
	Dry	Wetted	No.	Wetted area In hectares	Water	Freeboard	Intake In cubic metres per second	Holding In cubic metres	Short duration	Long duration
LACFCD										
Lopez	7.3	5.3	9	0.40 - 0.85	0.61	0.61	0.71	30 800*	0.42	0.20
Pacoima	68.4	47.3	36	0.20 - 3.56	1.1	0.61	11.30	493 000	2.83	1.13
Hansen	63.1	44.5	19	1.1 - 4.13	0.61	0.61	12.74	284 000	5.24	1.70
Branford	4.9	2.8	1	2.8	10.7	3.05	43.61**	167 000	0.03	0.03
Los Angeles										
Tujunga	75.3	52.6	23	1.21 - 4.9	0.61 - 1.2	0.61	11.33	322 000 691 000	10.99	2.83
Headworks	20.2	12.1	6	0.20 - 4.0	1.2	0.61	1.98	148 000	1.13	0.85
	In acres				In feet				In cubic feet per second	
	Dry	Wetted	No.	Wetted area In acres	Water	Freeboard	Intake In cubic feet per second	Holding In acre-feet	Short duration	Long duration
LACFCD										
Lopez	18	13	9	1.0 - 2.1	2	2	25	25*	15	7
Pacoima	169	117	36	0.5 - 8.8	3.5	2	400	400	100	40
Hansen	156	110	19	2.6 - 10.2	2	2	450	230	185	60
Branford	12	7	1	7	35	10	1,540**	135	1	1
Los Angeles										
Tujunga	186	130	23	3 - 12	2 - 4	2	400	261 - 560	388	100
Headworks	50	30	6	0.5 - 10	4	2	70	120	40	30

* Capacity reduced in 1971 San Fernando earthquake.
** Outflow capacity equals intake capacity.

The city relies on several sources: ground water from local basins, water imported via the Los Angeles Aqueducts from the Mono Basin-Owens River*, and water imported through MWD from the Colorado River via the Colorado River Aqueduct and Northern California via SWP's California Aqueduct. In a normal year, water from wells in Sylmar and San Fernando Basins supplies about 15 percent of the demand in the San Fernando Basin. Water from the Los Angeles Aqueducts serves the major portion of the basin within the city's service area.

The city has one connection at the Joseph Jensen Filtration Plant where SWP water can be delivered to the San Fernando Valley. Total capacity is 11.3 metres (400 cubic feet) per second.

In the San Fernando Basin, the city maintains both spreading grounds and a pumping and distribution system. Listed below are those facilities that might be used for the theoretical model.

Spreading Grounds. The spreading grounds of the City of Los Angeles are fenced to prevent unauthorized entry, and weeds are controlled by disking and scraping the top of the soil. The city operates its spreading grounds by a battery method.

Tujunga Spreading Grounds, opposite the LACFCD Branford Spreading Basin (Figure 11 and Table 4), are used to spread controlled flows of native water from Hansen Dam and, occasionally, releases from the Los Angeles Aqueducts.

Headworks Spreading Grounds are south of the Los Angeles River near the City of Burbank (Figure 7 and Table 4). They are used to spread water from the Los Angeles Aqueducts that had been stored in Chatsworth Reservoir in the western part of the valley, ground water from the Reseda area, industrial discharges, rising water, and surface runoff.

Pumping and Distribution. The City of Los Angeles has 115 active deep wells in the San Fernando Basin, ranging from 300 to 610 millimetres (12 to 24 inches) in diameter, with a maximum pumping capacity of 7.1 cubic metres (250 cubic feet) per second, equivalent to 617 000 cubic metres (500 acre-feet) per day. Most are in the southeast part of the basin (Figure 8). Through the 1974-75 water year, these wells had been pumping 78 cubic hectometres (63,000 acre-feet) annually, the maximum then allowed by the courts. In 1975-76, as a result of the Supreme Court decision, the city began extracting approximately 100 cubic hectometres (83,000 acre-feet) per year. Although this is sufficient to meet the needs of its water service area in the valley, most of this water is exported to other parts of the distribution system outside the San Fernando Basin.

Water from the North Hollywood well field (Figure 8) is pumped into a forebay at North Hollywood Pumping Station. It is discharged by gravity into a conduit, which parallels the Los Angeles River and terminates at a reservoir outside the basin. Enroute, the conduit receives the discharge of the Erwin, Whitnall, Verdugo, Headworks, and Crystal Springs wells. The pumping station also has the capability to discharge into trunklines that supply two other reservoirs outside the basin. These reservoirs serve a large portion of the Hollywood, central, and southern parts of the city.

Water from the Pollock wells (Figure 8) discharges into a trunkline at the southeast corner of the basin and flows with water from other sources to reservoirs outside the basin. The Deep Gallery wells extract water spread in the Headworks spreading grounds.

The first Los Angeles Aqueduct has a capacity to deliver 14 cubic metres (490 cubic feet) per second, equivalent

*The question of how much water the City of Los Angeles can pump from the Owens Valley in the future has yet to be determined. The resolution of litigation, along with solution of other legal and institutional issues, could have an effect on water to be stored in the San Fernando Basin.

to 121 000 cubic metres (980 acre-feet) per day. The average annual delivery, considering normal maintenance and shutdowns, is approximately 13 cubic metres (456 cubic feet) per second. The second aqueduct has the capacity to deliver approximately 8 cubic metres (290 cubic feet) per second, although for long-term operations the designed delivery rate is 6 cubic metres (210 cubic feet) per second. Thus, the combined capabilities of the first and second Los Angeles Aqueducts for long-term operation are 19 cubic metres (666 cubic feet) per second, or about 595 cubic hectometres (482,000 acre-feet) per year.

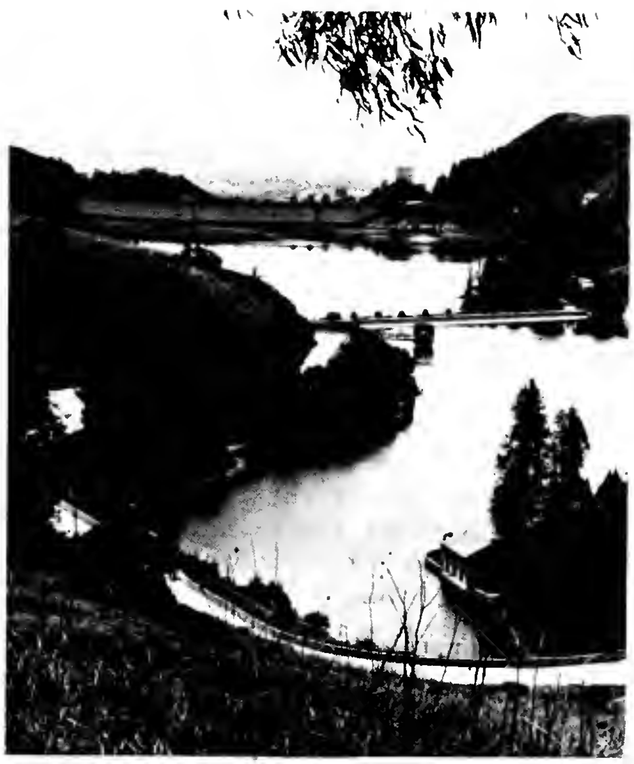
The Los Angeles Aqueducts bring water to the Van Norman Complex, which feeds various distribution reservoirs in the Santa Monica Mountains, Hollywood Hills, and foothills of the San Gabriel Mountains. Because these reservoir sites are at high points within, or adjacent to, a pressure zone, water stored in them feeds the distribution networks of the San Fernando Valley and Coastal Plain by gravity. Areas of the city that are higher in elevation than the gravity system are served by booster-pump stations.

In addition, three trunklines provide gravity service to certain high areas of the San Fernando Valley. They branch from the Los Angeles Aqueducts above the Van Norman Complex.

City of Burbank

The facilities of Burbank include 11 wells plus MWD connections, reservoirs, tanks, mains, meters, and services. Currently, 25,725 water services are metered. The total capacity of all the wells is 1.01 cubic metres (35.6 cubic feet) per second, or 32 cubic hectometres (25,800 acre-feet) per year (Figure 8).

During the 1975-76 water year, Burbank extracted about 6.4 cubic hectometres (5,200 acre-feet) from the San Fernando Basin and imported 22.8 cubic hectometres (18,500 acre-feet) of Northern California



HOLLYWOOD RESERVOIR, located in the Santa Monica Mountains just south of the San Fernando Basin, stores some of the water pumped from the basin by the City of Los Angeles.

water from MWD. No Colorado River water was delivered during that year. Before the California Supreme Court decision in 1975, the city was pumping 64 percent of its water and importing 36 percent.

Nine of the wells are near the main pumping plant. Total capacity of these wells is approximately 0.92 cubic metre (32.5 cubic feet) per second. They pump to the forebay of the plant, from which chlorinated water is delivered by the main booster pumps into the main distribution system, serving about 91 percent of the entire service area. Elevation of this system is 280 metres (904 feet).

The other two wells have a total pumping capacity of approximately 0.09 cubic metre (3.1 cubic feet) per second through a small forebay and a booster pump.

In addition to the wells, the city also has four locations within its main

pressure system where water can be delivered from MWD. Total capacity is 2.1 cubic metres (75 cubic feet) per second. A fifth connection of 0.57 cubic metre (20 cubic feet) per second is planned to start operation by 1980.

The water is distributed through the system by a network of facilities including booster pumps and storage structures. Operating pressure for each of the three pressure systems is regulated by a storage structure placed to provide a minimum of approximately 276 kilopascals (40 pounds per square inch) at the highest service supplied in that particular zone. The 21 reservoirs range in capacity from 49 cubic metres to 0.09 cubic hectometre (1,740 cubic feet to 77 acre-feet). Total storage capacity is approximately 0.19 cubic hectometre (153 acre-feet) when the water levels in all structures are in the operating range.

Water for two of the pressure systems is repumped from the main system. One system is a narrow service area between 244 and 274 metres (800 and 900 feet) in elevation and serves approximately 6 percent of the city. The other system is also a narrow service area between 274 and 305 metres (900 and 1,000 feet) in elevation and serves only 3 percent of the city.

City of Glendale

The water demand for the City of Glendale is approximately 32 cubic hectometres (26,000 acre-feet) per year.

Since the 1975 California Supreme Court decision, the city pumps only about 21 percent of its water and imports the other 79 percent from MWD.

The city's main pumping plant is on the north bank of the Los Angeles River near the Grandview wells (Figure 8). The city has nine wells in the San Fernando Basin approximately 150 metres (500 feet) deep with tested capacities ranging from 0.04 to 0.20 cubic metre (1.5 to 7.0 cubic feet) per second. Their total pumping capacity is approximately 0.85 cubic metre (30 cubic feet) per second, or 27 cubic hectometres (21,700 acre-feet) per year. At the main pumping plant the water is chlorinated and lime is added before it enters the settling basins, where suspended matter is removed.

In addition to these facilities, the city has three service connections to MWD for delivery of imported water. Total capacity of these connections is 2.05 cubic metres (72.5 cubic feet) per second.

Water is distributed throughout the Glendale service area by a network of more than 560 kilometres (350 miles) of pipelines and 22 booster stations and is regulated in 26 reservoirs and tanks with storage capacities ranging from 150 cubic metres to 0.22 cubic hectometre (5,350 cubic feet to 175 acre-feet). The storage facilities have a total capacity of about 0.67 cubic hectometre (540 acre-feet).

The 7 600-hectare (18,800-acre) water service area of Glendale has elevations ranging from about 130 to 730 metres (440 to 2,400 feet) above sea level. Because of this wide range, the distribution system is divided into six principal and four intermediate pressure zones. The system has 31,000 metered water connections.

City of San Fernando

San Fernando's principal source of supply is ground water from the Sylmar Basin. Although most of the city overlies the San Fernando Basin and it has rights to water in the basin, it has no wells in the basin.

The supply system consists essentially of four wells in the Sylmar Basin, two booster pumping stations, and five regulating storage reservoirs serving three pressure-distribution zones. The five reservoirs have a combined storage capacity of approximately 0.02 cubic hectometre (20 acre-feet).

TYPICAL WATER WELL in the San Fernando Basin

In addition to the wells, the supply system is connected with MWD for delivery of imported water. The connection has a capacity of 0.28 cubic metre (10 cubic feet) per second.

The Metropolitan Water District of Southern California

MWD has contracted for a maximum annual delivery through the West Branch of the California Aqueduct by 1990 of 1 795 cubic hectometres (1.455 million acre-feet) of SWP water per year. The average flow would be 57 cubic metres (2,010 cubic feet) per second. In addition, MWD has contracted for and funded excess capacity in the West Branch to allow for future maximum delivery of 2 467 cubic hectometres (2 million acre-feet) per year.

SWP water from the West Branch flows from Castaic Reservoir into MWD's treatment and distribution system via the Foothill Feeder, which has a present design capacity of 49.6 cubic metres (1,750 cubic feet) per second. A second barrel could be added to this feeder to give a maximum capacity of 99.1 cubic metres (3,500 cubic feet) per second.

The Foothill Feeder runs south from Castaic Reservoir through the Castaic, Saugus, and Newhall Tunnels to Magazine Canyon shaft in the northern San Fernando Valley, where it turns easterly through the San Fernando Tunnel and ends, at the present time, at Pacoima Wash. The design capacity of the San Fernando Tunnel is 62.3 cubic metres (2,200 cubic feet) per second.

Plans had been made to extend the Foothill Feeder to join an existing tunnel in San Gabriel Canyon, 64.4 kilometres (40 miles) to the east. At present, design and construction have been held in abeyance pending the outcome of analyses of the need for this reach and possible alternatives.

MWD's Joseph Jensen Filtration Plant is supplied with SWP water via the Balboa Inlet Tunnel, which branches from the Foothill Feeder at Magazine Canyon Shaft. The Balboa Inlet Tunnel has a design capacity of 42.5 cubic metres (1,500 cubic feet) per second. The Jensen Plant has a present design capacity of 26.3 cubic metres (930 cubic feet) per second; it delivers treated SWP water primarily to the MWD western service area via the Sepulveda, West Valley, Calabasas, East Valley, and Santa Monica Feeders (Figure 12).

Treated SWP water can also be delivered to the City of Los Angeles by way of a service connection at the Jensen Plant. This service connection has a maximum design capacity of 14.2 cubic metres (500 cubic feet) per second. Los Angeles water may be brought into the Foothill Feeder via an 11.3-cubic metre (400-cubic

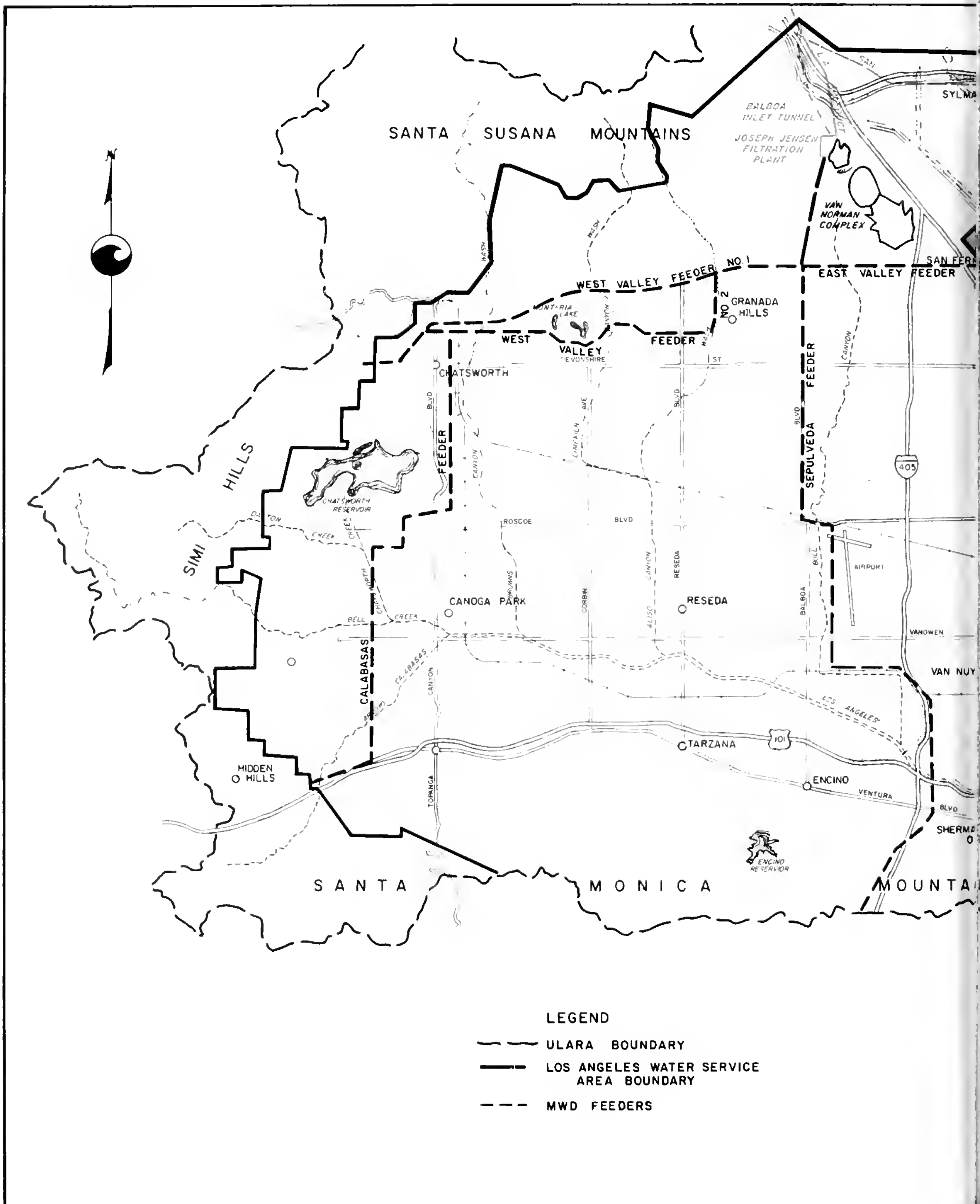


Figure 12

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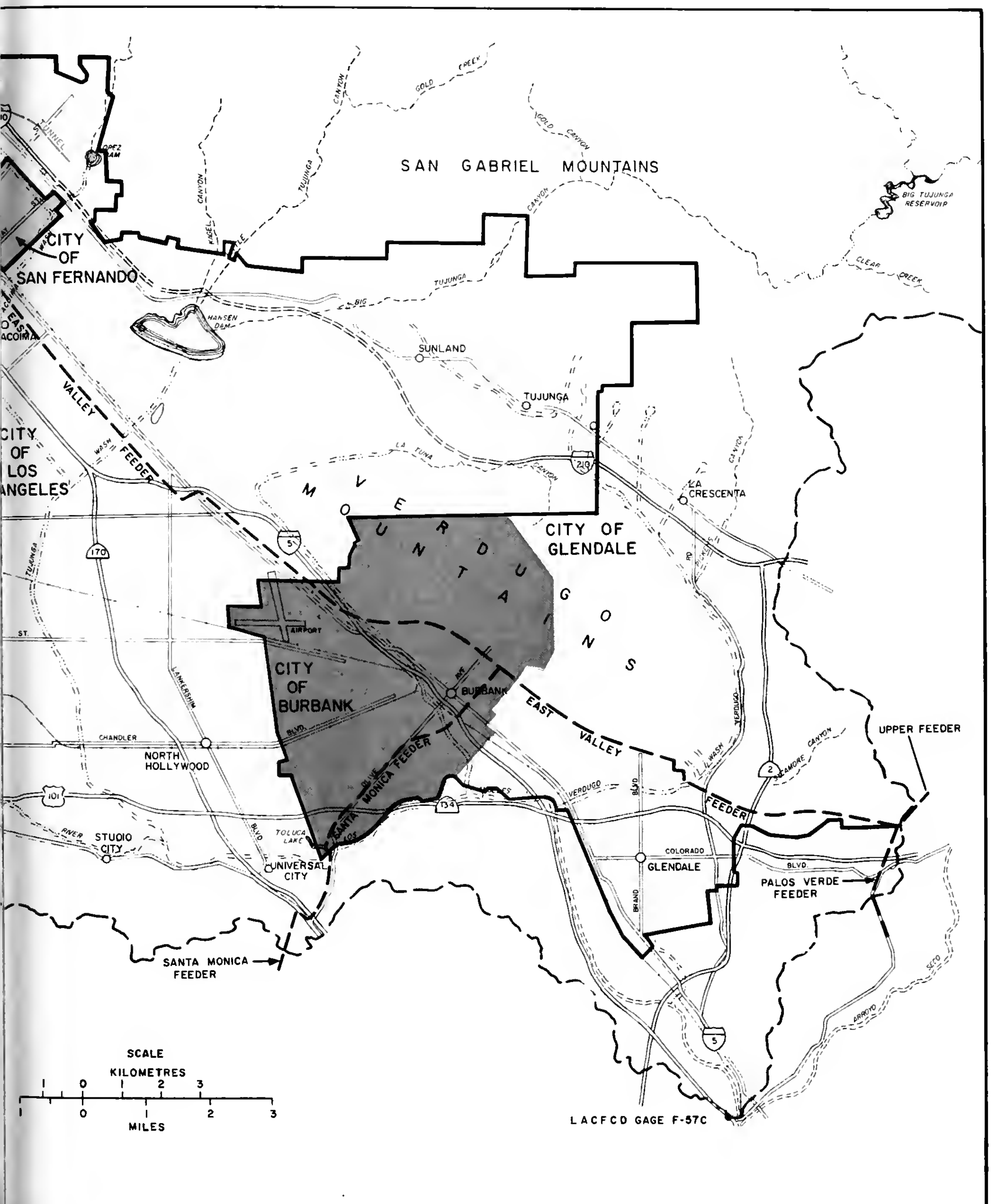

WATER SERVICE AREAS AND MWD FEEDERS
IN SAN FERNANDO VALLEY

foot) per second connection at Magazine Canyon Shaft from the Los Angeles Aqueduct.

In addition, blended and treated SWP water from the East Branch of the California Aqueduct and Colorado River water can, if needed, be brought into the San Fernando Valley through MWD's Upper Feeder to the East Valley and Santa Monica Feeders. The capacity of this route is approximately 2.8 cubic metres (100 cubic feet) per second.

State Water Project

The theoretical model for the San Fernando Basin is based on the assumption that enough SWP water to implement the model can be brought into Southern California by means of SWP facilities. This means that the capacity of the conveyance facilities, the water supply, and the available power (capacity and energy) must be sufficient to meet the needs of the model, as well as those for normal contracted deliveries.

As Figure 13 shows, the SWP facilities form a network that extends from Lake Oroville in Northern California to Lake Perris in Southern California, with branch aqueducts to the north and south San Francisco Bay areas, and the metropolitan Los Angeles area. Facilities to the Central Coastal area are yet to be built. By means of these facilities, water from runoff in Northern California and the Central Valley is stored and transported to State water contractors in other parts of Northern California (including the San Francisco Bay area), the Central Valley, and Southern California. The water is delivered in accordance with provisions of water supply contracts executed between the State and each of 31 public agencies.

Each contract includes a schedule for that agency's annual entitlements of water, which is shown as Table A in the contract. Although each agency retains the right to refuse delivery of its full annual entitlement, it must meet its obligation for fixed costs. The annual entitlements are generally small in the initial years, but increase gradually until the maximum is reached.* The combined total of the maximum annual entitlements of all agencies is 5 200 cubic hectometres (4.23 million acre-feet).

In Southern California, 13 water agencies hold contracts for 59 percent of this total, or 3 100 cubic hectometres (2,497,500 acre-feet) per year. MWD holds a maximum annual entitlement on both the West Branch and East Branch of 2 481 cubic hectometres (2,011,500 acre-feet).

Facilities

The SWP conveyance facilities that would be used for the theoretical model in the San Fernando Basin would include that part of the California Aqueduct between the Sacramento-San Joaquin Delta and the Tehachapi Afterbay and the West Branch of the aqueduct from the Tehachapi Afterbay to Castaic Lake. From Castaic, the water would be transported through the MWD delivery system to the San Fernando Basin.

The design capacity of the California Aqueduct exceeds that required to meet all contract entitlements at this time.

Water Supply

In the past, SWP water available for export from the Sacramento-San Joaquin Delta has exceeded the requests for entitlements except in drought years, such as 1977, when full annual entitlements could not be met. The volume of water requested as annual

*Because the yield in the early years of the SWP exceeds the annual entitlements, provision was made in the contracts for handling surplus water. Since 1974 most water contractors have amended the definition of surplus water as given in their contracts to include only such water as can be furnished contractors without interfering with (1) annual entitlements, (2) needs for SWP construction, (3) operational requirements for recreation and fish and wildlife uses, (4) needs for SWP power generation, (5) exchanges of water and variations in reservoir storage necessary for operational flexibility, and (6) losses in connection with the other five items.

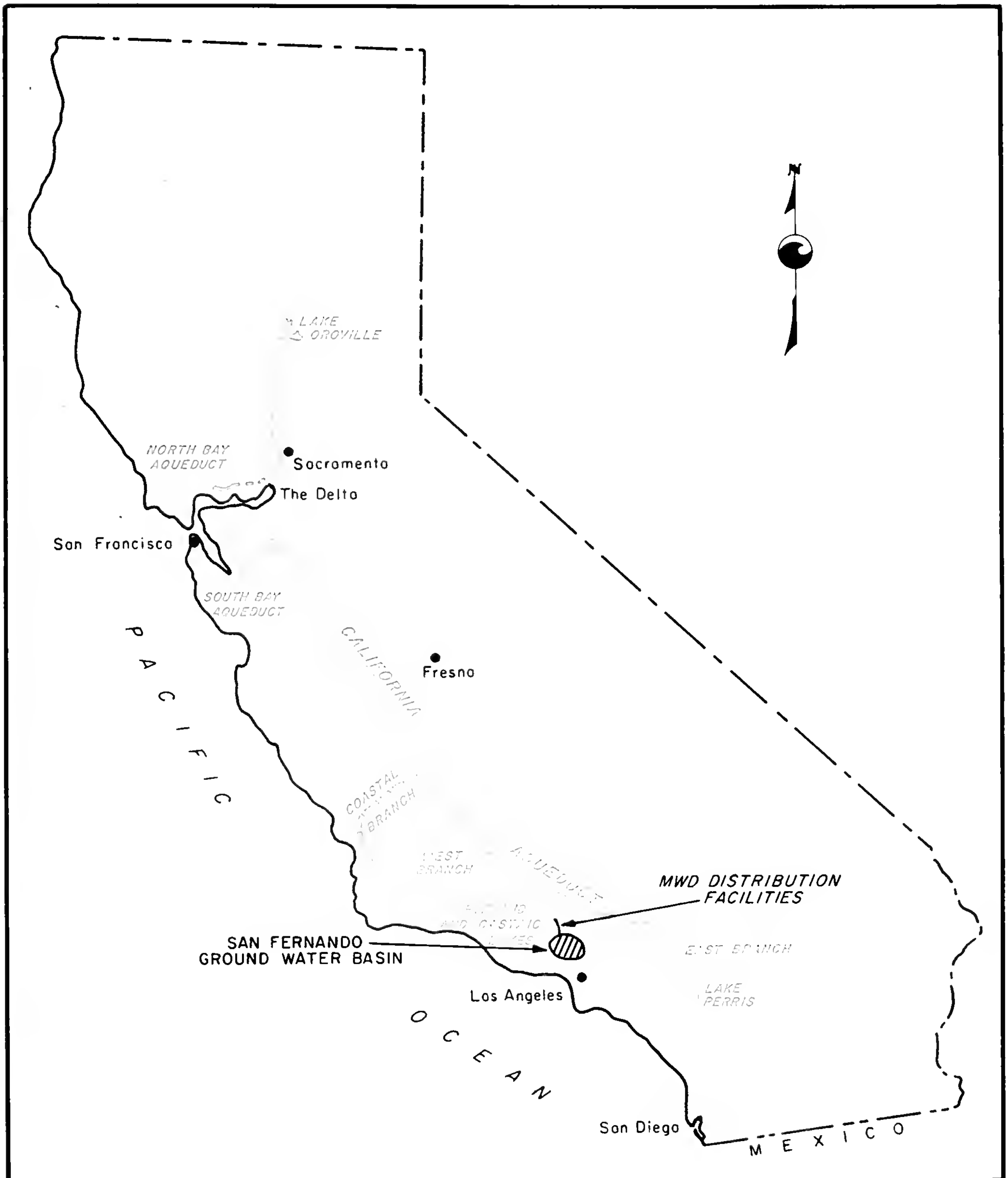

Figure 13 - STATE WATER PROJECT FACILITIES

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1978

entitlements is increasing and will eventually exceed SWP capabilities in all except wet years, unless the planned additional conservation facilities are completed.

As part of the development of the theoretical model, water supply and conveyance capabilities of the SWP were evaluated for the selected operational period and are discussed in Chapter IV.

Power

The power plants on the SWP generate a portion of the power required to operate its pumping plants. The remaining power required is purchased from outside suppliers under contract.

In 1975, the amount of energy produced by the SWP was 3 billion kWh and the amount consumed was 4 billion kWh. To deliver the maximum annual entitlements, the total amount of energy required will be approximately 13 billion kWh each year, of which only about 30 percent will be met from SWP recovery generation.

At present, the amount of energy required to pump 1 233 cubic metres (1 acre-foot) of water from the Delta to Castaic Lake exceeds the generating capability of the SWP by 3 200 kWh. The completion of Pyramid Powerplant in 1982 will bring this down to approximately 2 600 kWh.

For the theoretical model, water would flow by gravity through MWD's system from Castaic Lake to the San Fernando Valley, thus requiring no additional power until later pumped from the basin.

CHAPTER IV. THEORETICAL MODEL

Under the concept presented in this report, SWP water would be stored in ground water basins in times of plentiful supply and would be used in dry periods, just as would water in any surface conservation reservoir. (See box.) Once stored, this water would be designated as "SWP ground water". It would serve to increase the overall yield of the SWP, thus benefiting all 31 State water service contractors.

If the San Fernando Basin were used as one of the storage basins, its operation would have to be integrated into the operating plans of the overlying agencies and cities. In addition, an operating committee would be formed to have continuing responsibilities to ensure that management of the basin would be equitable to all parties.

However, the operation outlined in this report is only a theoretical model, designed to identify the various factors that would have to be considered in implementing a ground water storage program. To test integration of the program into operation of the SWP and the local agencies' management plans, a demonstration project would be carried out for a short period, probably not to exceed 10 to 15 years.

Development of Model

The theoretical model was developed by the engineering members of the advisory committee. The criteria used for developing the model are:

1. Limit capital cost by using existing recharge, transportation, and pumping facilities as much as possible.

2. Complete the initial fill within a comparatively short period (maximum of 7 years).

3. Operation be compatible with needs of local agencies in the basin.

Applying these criteria, the maximum amount agreed to for the theoretical model was 394.7 cubic hectometres (320,000 acre-feet). This amount is also large enough to give a clear indication of the physical reaction of the basin. Therefore, an operational schedule was formulated to store this amount of water and then to extract it within the limits of the "7-year dry period" for which the SWP is designed.* Thus it would provide a dry-period yield for the SWP of 59.2 cubic hectometres (48,000 acre-feet) per year for the duration of the schedule.

Although existing recharge facilities are adequate to store the designated amount of water, existing pumping and distribution facilities may not be. If the San Fernando Basin were used and the existing facilities proved to be inadequate, additional facilities would have to be installed or the amount of water stored be reduced.

Storage Alternatives

As stated previously, storage of the water could be accomplished by two methods. They are direct storage by spreading and indirect storage by interim delivery of surface water (in lieu of pumping) to areas normally using ground water. A combination of these two methods was decided upon for two reasons: (1) experience gained with this theoretical model will provide direction and guidance for the operation of ground water storage programs, and (2) combining the two methods will give an operational

*The SWP is designed to meet its contractual commitments (including deficiencies) even though a drought such as that experienced in the 7 years of 1928-34 were repeated.

flexibility that the advisory committee thought desirable.

Based on these considerations, the decision was made to study two storage combinations that represent the two extremes:

Combination 1. Store primarily by direct spreading,

Combination 2. Store primarily by the indirect method.

Both combinations require a certain amount of direct storage. To determine what facilities could be used for direct storage and what additional construction would be needed, alternative routes were mapped and evaluated for transporting the SWP water to existing spreading grounds (Table 5).

Route 1 (Figure 14) would require the least amount of additional construction, but it can only be used with combination 2 because it conveys water to only two spreading grounds. To study combination 1, additional spreading grounds would be required; therefore, routes 2-5 were developed (Figure 15).

Routes 4 and 5 were ruled out of further consideration because of their high cost of construction, the adverse impact they would have on the environment, and the institutional complications they would create.

The difference in cost between routes 2 and 3 is small, but the design of route 2 is more suitable for long-term operation. For this reason, route 2 was chosen for combination 1.

For the indirect storage portion of both combinations 1 and 2, no additional construction would be required. The Joseph Jensen Filtration Plant and existing MWD and city facilities would be used. However, the City of Los Angeles could not participate in any of the indirect storage without an amendment to the city charter

UNDERGROUND RESERVOIRS: DO

In considering the addition of ground water basins to the network of storage facilities of the State Water Project, an understanding of the nature and capabilities of the basins is important. A comparison with surface storage and delivery systems reveals many parallels, both physically and operationally.

Physical Comparison

- The storage capacity of a ground water basin is analogous to the storage capacity of a surface reservoir; both are subject to a certain amount of loss (such as to evaporation, subsurface outflow, seepage, and consumptive use by phreatophytes). Usually, these losses are less for ground water basins.
- The rate of deep percolation and subsurface inflow to a ground water basin corresponds to the rate of inflow into a surface reservoir.
- A subsurface delivery system has a starting point (streambeds and spreading grounds) and a terminal point (wells), just as does a surface system.
- The transmissive characteristics of the aquifers of a ground water basin are comparable to the delivery characteristics of a surface distribution system.
- The piezometric pressure and ground water table may be likened to the hydraulic grade line elevations in a surface distribution system.
- With the use of equations that describe the flow characteristics of a ground water basin, its capabilities can be calculated, just as can those of a surface system with the use of its particular equations.
- Conversely, an underground reservoir is not a vast pit, as is a surface reservoir. A subsurface reservoir consists of many particles of sand, gravel, or other sediments that lie loosely upon each other; the storage space occupied by water is the many tiny void spaces surrounding each particle.
- Because it consists of many minute storage spaces, an underground reservoir does not empty uniformly as does a surface reservoir and, in truth, it can never be completely drained dry

THEY PRESENT UNIQUE PROBLEMS?

because some water will always remain attached to the particles of sand or gravel.

Operational Comparison

Adding a surface reservoir to the storage facilities of the State Water Project would require the construction of the reservoir and facilities to get water in and out for delivery to the using agencies. However, the process would not be that simple if the only land available already contained a reservoir that was being used by local agencies and it was fully equipped with facilities for taking water in and out--which is comparable to the situation in the San Fernando Basin.

Under those circumstances, the State would seek to reach agreement with the local agencies so that it could use a portion of the storage space and a portion of the input and output facilities.

To get the water into storage, the State would find it could either (1) deliver water directly to the reservoir for storage or (2) deliver it directly to the users, who would give assurance that they would cut back their deliveries from the reservoir by an equivalent amount. In that case, ownership of the water they allowed to remain in storage would pass to the State.

Among the legal and institutional questions either arrangement would pose are:

- How could use of the reservoir be extended to include another party (in this case, the State) without affecting the use by other parties?
- How could everyone be sure that the increased use introduced by this new party would not damage the reservoir, its facilities, or the water itself?
- What payment mechanisms could be established to ensure equitable payment to all parties?
- How can assurance be given to all parties that their legal rights to the water in the reservoir would not be endangered?

Thus the dilemma faced by the parties in this program is much the same as that they would face if the reservoir to be added were aboveground rather than belowground.

permitting the exchange of water to which it holds a right.

Recapture Options

Physically, recapture could be achieved by any of several options. These are:

- Option 1. Each of the cities now pumping from the basin would pump SWP ground water, chlorinate it, and use it instead of an equal amount of imported treated water delivered by MWD. Therefore, each of the cities would cut back a portion of its surface delivery by a prearranged amount. Pumping this additional water could require the construction of additional wells and pipelines, depending upon the amount of annual recapture decided upon.

- Option 2. The Cities of Los Angeles, Glendale, and Burbank would pump a specific amount of SWP ground water, chlorinate it, and deliver it into MWD's distribution system for use where needed. However, the use of existing facilities for this reverse flow would necessitate construction of valving to allow the introduction of water into MWD's pipelines at pressures higher than those of MWD's system. This would also result in an energy loss.

- Option 3. In Magazine Canyon, the City of Los Angeles would deliver imported water from the Los Angeles Aqueducts to MWD's Balboa Inlet Tunnel (for transport to the Jensen Plant and delivery where needed in MWD's system) in exchange for MWD's right to an equal amount of SWP ground water. This option would require an amendment to the charter of the City of Los Angeles to permit exchange of its water.

- Option 4. A three-way agreement involving MWD and the Cities of Los Angeles and San Fernando would have to be worked out to permit exchange of water from Sylmar and San Fernando

TABLE 5
CONSTRUCTION NEEDED FOR ALTERNATIVE ROUTES
FOR DIRECT STORAGE*

Route	Spread water at	Construction needed
1	*Lopez Spreading Grounds and Pacoima Spreading Grounds*	*Connection 3* (from San Fernando Tunnel to Pacoima Wash Channel) 335 metres (1,100 feet) of 0.9-metre (36-inch) diameter pipe + impact stilling basin. Total capacity: 1.4 cubic metres (50 cubic feet) per second.
2	*Lopez Spreading Grounds, Pacoima Spreading Grounds, Branford Spreading Basin, and Tujunga Spreading Grounds*	*Connection 3* 335 metres of 1.1 metre (42-inch) diameter pipe + impact stilling basin. Total capacity: 4.2 cubic metres (150 cubic feet) per second. *Connection 1A* (from Pacoima Wash Channel to LACFCD storm drain) Inflatable fabric dam + 792 metres (2600 feet) of 1.2-metre (48-inch) diameter pipe. Total capacity: 2.8 cubic metres (100 cubic feet) per second.
3	*Lopez Spreading Grounds, Pacoima Spreading Grounds, Branford Spreading Basin, and Tujunga Spreading Grounds*	*Connection 3* (same as for route 2) *Connection 1B* (from Pacoima Diversion Channel to Branford Spreading Basin to Tujunga Spreading Grounds) Inflatable fabric dam + 1.2-metre diameter diversion structure + 244 metres (880 feet) of 1.2-metre diameter pipe + raising dikes surrounding Branford Spreading Basin by 1.5 metres (5 feet) + 107 metres (350 feet) of 1.2-metre diameter pipeline (of which, 46 metres, or 150 feet, would be steel pipe over Tujunga Wash Channel). Total capacity: 2.8 cubic metres (100 cubic feet) per second.
4	*Lopez Spreading Grounds, Pacoima Spreading Grounds, Hansen Spreading Grounds, and Tujunga Spreading Grounds*	*Connection 3* (from San Fernando Tunnel to a 1.2 by 0.6-metre, or 48 by 24-inch, wye connector to Pacoima Wash Channel) 1.2-metre diameter pipe + wye connector, with flow meters in both branches + 0.6-metre diameter pipe + impact stilling basin. Total capacity: 5.9 cubic metres (210 cubic feet) per second. *Connection 2A* (from wye connector to Lopez Canyon Channel) 1.2-metre diameter pipe (part of which would be steel pipe over Pacoima Wash Channel and part would be through a freeway interchange). Total length of construction: 2.3 kilometres (7,700 feet). Total capacity: 4.5 cubic metres (160 cubic feet) per second.
5	*Lopez Spreading Grounds, Pacoima Spreading Grounds, Hansen Spreading Grounds, and Tujunga Spreading Grounds*	*Connection 3* (from San Fernando Tunnel to a 1.4 by 0.6-metre, or 54 by 24-inch, wye connector to Pacoima Wash Channel) 1.4-metre diameter pipe + wye connector, with flow meters in both branches + 0.6-metre diameter pipe + impact stilling basin. Total capacity: 5.9 cubic metres (210 cubic feet) per second. *Connection 2B* (from wye connector to Lopez Canyon Channel) 1.4-metre diameter pipe (part of which would be steel pipe over Pacoima Wash Channel and part would require an 18-metre, or 60-foot, deep cut through a hillside + impact stilling basin + 0.8 kilometre (2,700 feet) of lined channel. Total length of pipeline: 1.6 kilometres (5,400 feet). Total capacity: 4.5 cubic metres (160 cubic feet) per second.

*All the routes are described for maximum operation; if a smaller amount of SWP water were to be spread, fewer spreading grounds could be used or the apportionment varied.

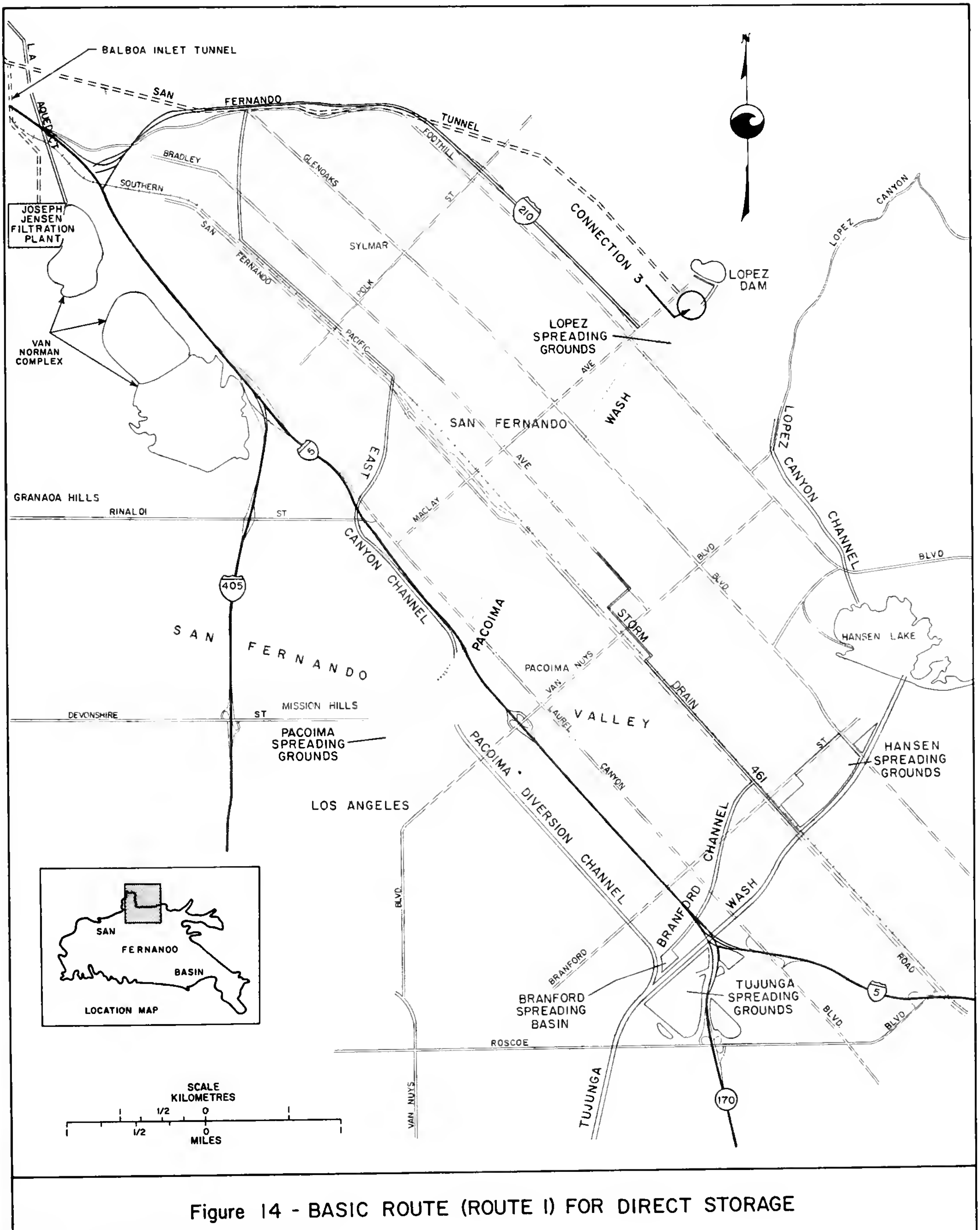

Figure 14 - BASIC ROUTE (ROUTE I) FOR DIRECT STORAGE

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1978

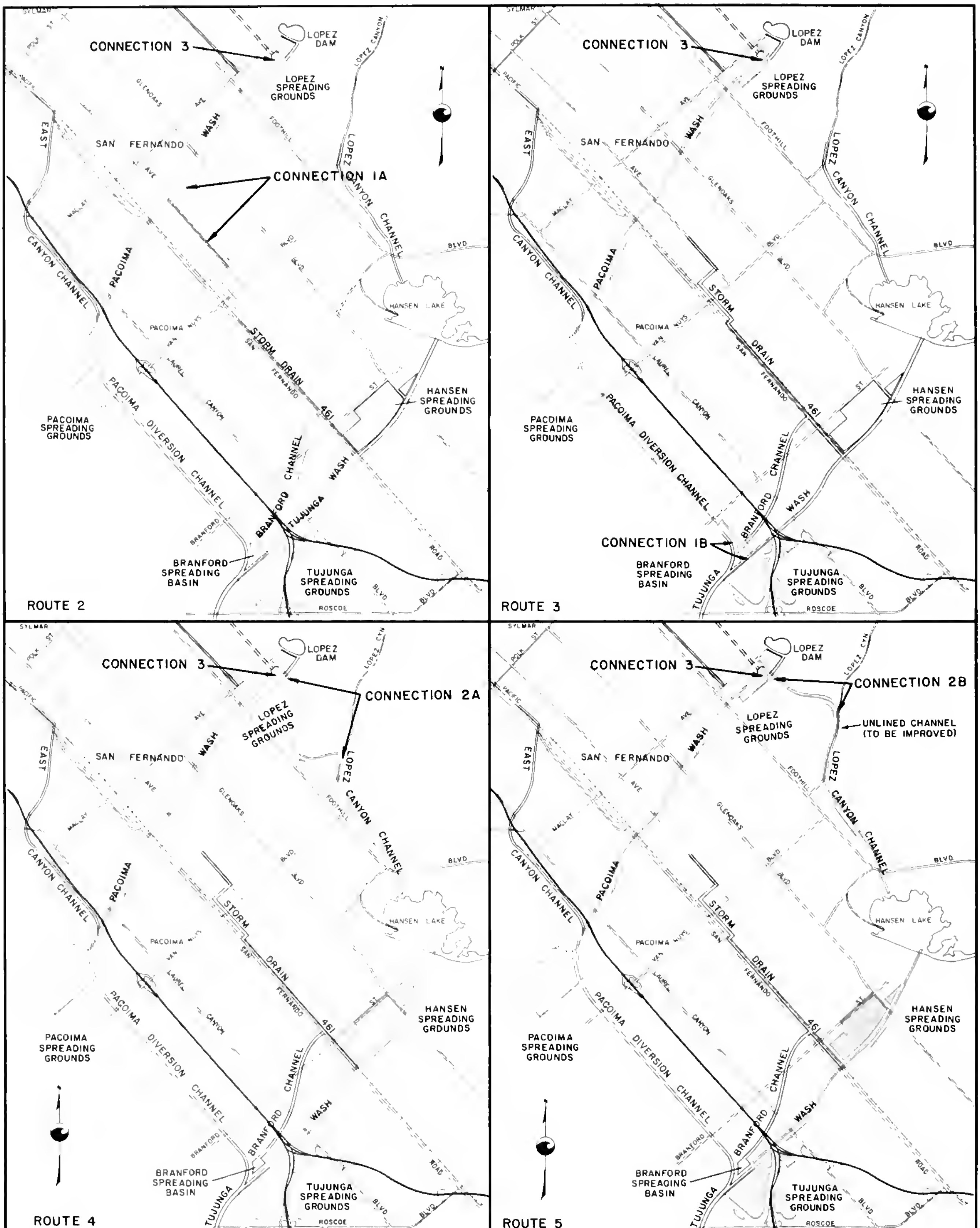

Figure 15 - ADDITIONAL ROUTES FOR DIRECT STORAGE

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1978

Basins, in which both cities hold rights. Under this option, San Fernando would cut back its surface deliveries from MWD and pump an equal amount of water from Sylmar Basin, to which Los Angeles now holds rights. Los Angeles, in turn, would pump an equal amount of SWP ground water from the San Fernando Basin. Because the City of San Fernando uses such a small amount of MWD water, this option does not appear to be practical. This option would also require an amendment to the Los Angeles city charter.

- Option 5. As a variation of option 4, the City of San Fernando would use SWP ground water pumped by the City of Los Angeles from the San Fernando Basin in exchange for the water that San Fernando would normally receive on the surface from MWD. This option has the same disadvantages as does option 4.

To simplify the analysis, the three options requiring a charter amendment (options 3, 4, and 5) were eliminated. Of the remaining two, option 1 is considered more practical because it does not require reversal of flows within the various distribution systems, which could create water quality problems by removing scale.

Therefore, the decision was made to use option 1 for recapture for the theoretical model.

Operational Schedule

Using the information developed thus far in the study, an operational schedule, to start in 1976, was designed for the theoretical model (Table 6).* Under this schedule, 394.7 cubic hectometres (320,000 acre-feet) of SWP water would be stored in the San Fernando Basin over an initial 6- to 7-year span, followed by a 5-year recapture period. This would be succeeded by a second cycle with a 5- to 6-year storage period and a 5-year recapture period.

It should also be noted that the operational schedule in Table 6 shows arbitrary storage and recapture cycles designed to test the various effects of the cycles. For a long-term storage program, the storage and recapture cycles would be based on actual hydrologic conditions at that time.

According to the schedule in Table 6, combination 1 (primarily direct storage) would store about 80 percent of the water by direct spreading, using route 2. Combination 2 (primarily indirect storage) would store about 65 percent of the water indirectly with the remaining 35 percent stored directly by way of route 1.

Operational Studies

After the theoretical model was developed, operational studies were undertaken to verify the SWP's capability to deliver to Castaic Lake the additional amount of water called for in the operational schedule, MWD's ability to transport the water to the basin, and the local agencies' ability to store and recapture the water.

The SWP's ability to deliver water depends upon the amount of water available to it, its conveyance capacity, and the power required to pump the water.

For each 5-year period, the Department of Water Resources estimates the amount of SWP water available for export from the Sacramento-San Joaquin Delta. For 1976-81 the estimates are 8 300 cubic hectometres (6.7 million acre-feet) under median quartile** Delta supplies

*Note that for the entire operational schedule shown, MWD's deliveries are expected to be below maximum entitlement of SWP water.

**Median quartile years are considered as "normal" years; they are years in which at least 19 366 cubic hectometres (15.7 million acre-feet) of water is available to the Sacramento-San Joaquin Delta. Lower quartile years are drier than normal; the amount available to the Delta is expected to be equaled or exceeded 75 percent of the time.

TABLE 6
TWO STORAGE COMBINATIONS: SCHEDULES FOR STORAGE AND RECAPTURE

Calendar year	Combination 1 Storage					Combination 2 Storage				
	Direct		Indirect		Both	Direct		Indirect		Both
					In cubic hectometres					
1976	3.7	+	2.5	=	6.2	2.5	+	3.7	=	6.2
1977	13.5	+	9.9	=	23.4	12.3	+	21.0	=	33.3
1978	70.3	+	16.0	=	86.3	24.7	+	49.3	=	74.0
1979	80.2	+	18.5	=	98.7	24.7	+	49.3	=	74.0
1980	80.2	+	18.5	=	98.7	24.7	+	49.3	=	74.0
1981	66.6	+	14.8	=	81.4	24.7	+	49.3	=	74.0
1982						22.2	+	37.0	=	59.2
1976-82	314.5	+	80.2	=	394.7	135.8	+	258.9	=	394.7
1983			*Recapture*		-74.0			*Recapture*		-74.0
1984			*Recapture*		-74.0			*Recapture*		-74.0
1985			*Recapture*		-74.0			*Recapture*		-74.0
1986			*Recapture*		-74.0			*Recapture*		-74.0
1987			*Recapture*		-74.0			*Recapture*		-74.0
1983-87			*Recapture*		-370.0			*Recapture*		-370.0
1988	17.3	+	12.3	=	29.6	14.8	+	24.7	=	39.5
1989	70.3	+	16.0	=	86.3	24.7	+	49.3	=	74.0
1990	80.2	+	18.5	=	98.7	24.7	+	49.3	=	74.0
1991	80.2	+	18.5	=	98.7	24.7	+	49.3	=	74.0
1992	66.6	+	14.8	=	81.4	24.7	+	49.3	=	74.0
1993						22.2	+	37.0	=	59.2
1988-93	314.5	+	80.2	=	394.7	135.8	+	258.9	=	394.7
1994			*Recapture*		-74.0			*Recapture*		-74.0
1995			*Recapture*		-74.0			*Recapture*		-74.0
1996			*Recapture*		-74.0			*Recapture*		-74.0
1997			*Recapture*		-74.0			*Recapture*		-74.0
1998			*Recapture*		-74.0			*Recapture*		-74.0
1994-98			*Recapture*		-370.0			*Recapture*		-370.0
Total storage	629.0		160.4		789.4	271.6		517.8		789.4
Total recapture					-740.0					-740.0
Amount left in storage					49.4					49.4
					In acre-feet					
1976	3,000	+	2,000	=	5,000	2,000	+	3,000	=	5,000
1977	11,000	+	8,000	=	19,000	10,000	+	17,000	=	27,000
1978	57,000	+	13,000	=	70,000	20,000	+	40,000	=	60,000
1979	65,000	+	15,000	=	80,000	20,000	+	40,000	=	60,000
1980	65,000	+	15,000	=	80,000	20,000	+	40,000	=	60,000
1981	54,000	+	12,000	=	66,000	20,000	+	40,000	=	60,000
1982						18,000	+	30,000	=	48,000
1976-82	255,000	+	65,000	=	320,000	110,000	+	210,000	=	320,000
1983			*Recapture*		-60,000			*Recapture*		-60,000
1984			*Recapture*		-60,000			*Recapture*		-60,000
1985			*Recapture*		-60,000			*Recapture*		-60,000
1986			*Recapture*		-60,000			*Recapture*		-60,000
1987			*Recapture*		-60,000			*Recapture*		-60,000
1983-87			*Recapture*		-300,000			*Recapture*		-300,000
1988	14,000	+	10,000	=	24,000	12,000	+	20,000	=	32,000
1989	57,000	+	13,000	=	70,000	20,000	+	40,000	=	60,000
1990	65,000	+	15,000	=	80,000	20,000	+	40,000	=	60,000
1991	65,000	+	15,000	=	80,000	20,000	+	40,000	=	60,000
1992	54,000	+	12,000	=	66,000	20,000	+	40,000	=	60,000
1993						18,000	+	30,000	=	48,000
1988-93	255,000	+	65,000	=	320,000	110,000	+	210,000	=	320,000
1994			*Recapture*		-60,000			*Recapture*		-60,000
1995			*Recapture*		-60,000			*Recapture*		-60,000
1996			*Recapture*		-60,000			*Recapture*		-60,000
1997			*Recapture*		-60,000			*Recapture*		-60,000
1998			*Recapture*		-60,000			*Recapture*		-60,000
1994-98			*Recapture*		-300,000			*Recapture*		-300,000
Total storage	510,000	+	130,000	=	640,000	220,000	+	420,000	=	640,000
Total recapture					-600,000					-600,000
Amount left in storage					40,000					40,000

and 4 690 cubic hectometres (3.8 million acre-feet) under lower quartile Delta supplies, according to operation studies for Bulletin 132-76.* These estimates are based on a statistical analysis of hydrologic conditions in water years 1922 through 1954, modified to reflect the projected 1980 levels of development and water use upstream and within the Delta.

Using these modified supply figures, an operational study was made of the U. S. Bureau of Reclamation's Central Valley Project and the SWP. It observed such operational constraints as fishery release agreements, power contracts, recreational levels, water service contracts (including annual entitlements and surplus deliveries) and water quality requirements established by the State Water Resources Control Board for the Delta in 1975.**

From the operational study, it was found that, without a Delta facility and the additional pumps at the Delta Pumping Plant (which is the case for the 1976-81 period), the delivery capability of the SWP in a lower quartile year is only about 3 600 cubic hectometres (2.9 million acre-feet) and in a median quartile year about 4 560 cubic hectometres (3.7 million acre-feet). These amounts, however, are somewhat reduced by conveyance losses in the California Aqueduct.

Thus, even in lower quartile years and without additional conservation facilities, the SWP could supply requested entitlements, including water for the theoretical model, until the mid-1980s. However, in drought years--such as 1977--water would not be sufficient for deliveries for both requested entitlements and ground water storage. (In an actual ground water storage program, as opposed to the theoretical model being discussed here, recapture would be carried out in a year like 1977.) After the mid-1980s, as requests continued to increase, the SWP would not be able to supply both the requests and the ground water storage program without additional conservation facilities. Some water may be available for surplus deliveries during the early stages of the theoretical model, but the amounts would diminish in the early 1980s.

For this report, the assumption was made that sufficient water would be available throughout the operational schedule.

Also, the assumption was made that the power necessary for pumping additional water from the Delta to Castaic Lake for ground water storage could be ordered in advance, just as for any other entitlement water. This means that sufficient power would be available for operating the theoretical model.

Because the proposed demonstration project would be a planned operation, power for it could probably be ordered in advance also.

The present contracts for purchasing power from outside suppliers for the SWP will expire on March 31, 1983, but negotiations are now under way for new contracts. If ground water storage is selected as one of the means of meeting future water demand, provision for this power will undoubtedly be included in the new contracts.

A comparison of the capacity of MWD's transportation facilities with its maximum annual contracted deliveries from the West Branch of the California Aqueduct shows sufficient capacity remains to transport additional SWP water from Castaic Lake for storage.

*Bulletin 132-76, "The California State Water Project in 1975", California Department of Water Resources, June 1976.

**These supplies represent the amount of water available for export by the State under terms of the draft Central Valley Project--SWP Coordinated Operation Agreement, provided that Delta water quality objectives of the Water Quality Control Plans for Basins 2 and 5B are maintained. These Basin Plans were prepared in accordance with the Clean Water Act and California's Porter-Cologne Water Quality Act. Since the study reported in this bulletin was completed, the State Water Resources Control Board has amended the water quality objectives for the Delta with its Decision No. 1485.

The advisory committee agreed that the local agencies have the physical capability to take, by indirect storage, at least 49.4 cubic hectometres (40,000 acre-feet) per year, which is the maximum called for under the operational schedule for the theoretical model. For the direct storage portion, it was determined that 60 percent of the capacity of the spreading grounds would be available for the SWP water. This would allow spreading of at least 80.2 cubic hectometres (65,000 acre-feet) per year, which is the maximum under the operational schedule.

The ability of the local agencies to recapture the water depends upon their capability to pump, distribute, use, and exchange water.

The Cities of Burbank and Glendale have indicated they have sufficient reserve pumping capacities to recapture their share of the water under option 1, which would be 15 percent for each.

The City of Los Angeles would require additional wells and distribution facilities to recapture its share--70 percent of the water--by option 1. However, the amount of water bought by the City of Los Angeles from MWD varies from year to year and, in any given year, could be less than 70 percent. This would reduce the amount that could be recaptured, unless Los Angeles were permitted, by charter amendment, to exchange water. For the theoretical model, the assumption was made that the voters would approve the amendment.

However, for a demonstration project in which a smaller amount of water would be stored, present facilities of all the cities should be adequate for recapturing SWP ground water, even for option 1.

Management Plan

Under the management plan developed for the theoretical model, MWD would have to increase its Table A annual entitlements to accommodate the water needed for the ground water storage program. This decision was made because MWD is not now at maximum entitlement. When deliveries reach that point, DWR would increase the annual entitlement to accommodate the SWP ground water storage program. In this way, the program could be operated under existing contracts, and the ground water storage water would be given the

LOOKING NORTHWEST toward Pacoima Spreading Grounds. Pacoima Diversion channel is shown in the right foreground. These spreading grounds would be used in the direct storage of both combinations developed for the theoretical model.

same priority in aqueduct scheduling as entitlement water. However, the deliveries for ground water storage would be scheduled to minimize both power costs and the effect upon deliveries of surplus water.

According to the plan, storage and recapture operations would be handled by the local agencies, but overall operation would be administered by an operating committee, responsible to all participants. The operating committee would comprise one member each from the participating agencies--the Department of Water Resources, MWD, the Cities of Burbank, Glendale, Los Angeles, and San Fernando, and LACFCD.

For the theoretical model, all requests initiating the storage of SWP water or recapture of SWP ground water would be made by the Department of Water Resources to MWD, which would convey the requests to the operating committee and notify all the local agencies involved.

Determination of the capability of complying with the requests would lie with the operating committee. However, the operating committee would not be permitted to reduce annual amounts for storage or recapture below the guaranteed minimum amount that each participant had agreed to store or recapture over a period of one water year, unless an emergency arose. The guaranteed minimum amounts would serve to ensure a firm yield for the SWP.

Under the management plan for the theoretical model, the operating committee would test each phase of the operation ahead of time on the City of Los Angeles' computer model of the basin. By means of this computer model, the operating committee could evaluate the volume of water that could be stored or pumped, could determine what pumping patterns should be used to control both water levels and rising water, and could predict changes in water quality resulting from the operation.

To monitor effects within the basin, the operating committee would select a number of key wells for periodic measuring analysis.

If, under the guidelines for administering this program, the operating committee concurred with the Department's request to store SWP water in the basin, the operating committee would also determine the volume that could be safely stored and the proportion of direct and indirect storage to be used and would approve yearly and monthly storage schedules within the basin. The operating committee would be obligated to:

1. Make every effort to store the minimum guaranteed volume of SWP water in a reasonable period of time.

2. Coordinate operation of the SWP ground water storage with the management plans of the local agencies for storage in the basin.

3. Ensure that the ground water storage program is operated within the individual capabilities of each local agency or city.

4. Safeguard all water stored in the basin by eliminating or minimizing losses to rising water.

5. Prevent deterioration of quality of water stored in the basin resulting from interaction of the ground water table and sanitary landfills.

6. Prevent damage from a high ground water table.

In determining the proportion of direct and indirect storage, the operating committee also would have the obligation to make every effort to minimize the total cost to the State.

A similar evaluation procedure would be followed in approving the recapture of SWP ground water. The operating committee would determine how the water would be recaptured and would approve yearly and monthly recapture schedules within the

basin. These schedules would also be based on the ability of the cities to recapture and use the added amount, to deliver it to MWD, or to exchange other waters for SWP ground water stored in the basin. If the water recaptured is to be used instead of surface deliveries of MWD water (recapture option 1), the amount recaptured would correspond to the amount of surface delivery cut back that year. The minimum amount of this cutback would be agreed upon by local agencies.

Protection of rights to all water stored in the basin would also require supervision by a court-appointed administrator (watermaster).

In all cases, the records of storage, recapture, and loss of the SWP ground water would be maintained.

Need for Demonstration Project

Many questions remain to be answered, particularly those pertaining to the use of energy and the scheduling of storage and recapture operations for both the SWP and the basin. For this reason, a demonstration project is proposed to help find solutions to these questions. Actual storage and recapture operations are necessary to test the validity of various management and administrative procedures and to develop a plan to minimize energy requirements.

In the discussions now under way for the administration and operation of the demonstration project, details being discussed include:

1. Type of administrative agency. The concepts range from that of a multimember operating committee, similar to the one developed for the theoretical model, to a watermaster operation.

2. Legal title to the water. Ideas range from State ownership of the stored water, as in the theoretical model, to local ownership with the State reserving the right to cut back deliveries by an amount equal to that stored in the basin.

3. Term of storage. For the demonstration project, the length of time that water would remain in storage in the ground water basin would probably be 10 to 15 years initially, unless it were needed to meet entitlement requests in dry years that fell during the period set aside for initial storage.

4. Volume of storage. A short-term storage project would probably require no more than 123 cubic hectometres (100,000 acre-feet) of water.

CHAPTER V. LEGAL BASIS

During the early feasibility studies leading to the SWP, consideration was given to the use of ground water basins as storage reservoirs. A number of institutional and legal problems made their use undesirable, and the initial network consists of surface facilities only. With the removal, through recent court decisions, of some of the major institutional and legal problems* that had earlier deterred use of the ground water basins, the conjunctive operation of the basins with the SWP has been included as one of the additional conservation facilities to be investigated.

These court decisions, as well as the statutory authority for the inclusion of ground water storage in the SWP, are discussed below. However, before such ground water storage could be undertaken in a specific basin, the participants would have to work out a number of administrative and operational matters; this would call for agreements among the participants. Those proposed under the management plan for the theoretical model are also discussed in this chapter.

Statutory Authority

The California Water Resources Development Bond Act, California Water Code Section 12930, et seq., also known as the Burns-Porter Act, provides authority and funds to assist in the construction of the "State Water Resources Development System". The SWP is part of the system. The SWP ground water storage is authorized and may be funded by this act and by the Central Valley Project Act, Section 11100, et seq., which is incorporated in the Burns-Porter Act.

Under the Burns-Porter Act, the Central Valley Project Act, and the water supply contracts, the Department is given broad authority to develop the facilities and means of construction and operation that would provide SWP water in the amounts and at the time it is needed.

The State Supreme Court in Metropolitan Water District v. Marquardt [59 Cal.2d 159 (1963)] held that the broad discretion granted the Department was not an unconstitutional delegation of legislative powers. The court concluded its discussion of this issue by stating:

> "Here, ..., the conduct of an important public enterprise requires that broad power and discretion be granted to the administrative agency in charge of the project."

Later, the court interpreted Water Code Section 11454 (Central Valley Project Act) as follows:

> "Section 11454...made applicable by Section 12931, gives the Department broad powers and discretion to enter into contracts and to do all things which in its judgment are necessary, convenient, or expedient for the accomplishment of the purposes of the State Water Resources Development System."

This expansive Supreme Court interpretation of the Department's authority makes clear that the Department has discretionary powers to determine what facilities should be constructed. The courts have recognized that this kind

*The City of Los Angeles v. City of San Fernando, 14 Cal.3d 199 (1975) and Niles Sand and Gravel Company, Inc. v. Alameda County Water District, 37 Cal.App.3d 924 (1974), hearing denied, Cal. Sup. Ct. May 8, 1974, cert. denied, 419, U. S. 869 (1975).

ROUTES 2 THROUGH 5 would use Branford Spreading Basin (in foreground) and Tujunga Spreading Grounds, which are on the far side of Tujunga Wash in this photograph. Pacoima Diversion channel is the lined channel curving to the right of Branford Spreading Basin.

of flexibility is necessary in such a large and long-term enterprise as the SWP.

The State Water Resources Development System is specifically defined in Water Code Section 12931 as:

> "... comprised of the State Water Facilities as defined in Section 12934(d) hereof and such additional facilities as may now or hereafter be authorized by the Legislature as a part of (1) the Central Valley Project or (2) the California Water Plan, and including such other additional facilities as the department deems necessary and desirable to meet local needs, including, but not restricted to, flood control, and to augment the supplies of water in the Sacramento-San Joaquin Delta and for which funds are appropriated pursuant to this chapter."

A ground water storage program would be implemented as an "additional facility" under Section 12931.

The foregoing discussion of the Department's statutory authority with regard to ground water storage demonstrates the Department's authority to implement long-term ground water storage programs as part of the SWP. However, the allocation of such costs and the method of financing and repayment will be the subject of discussions and negotiations with the water service contractors when specific projects have been defined.

Under the management plan for the theoretical model, one way in which the Department intends to augment the basin's water supply is through indirect storage. Water Code Sections 1005.1 and 1005.2 provide that the "cessation of or reduction in" pumping by the owner of the right to extract and by the user of the water is a reasonable beneficial use of that water if the water received from the alternative source (in this case, the SWP) is applied to beneficial uses. Although these sections protect

the pumper who does not pump in an "exchange" arrangement from losing the water right, they do not address the question of who owns the unpumped water remaining underground.

It may be inferred from these sections that the agency which pays for the alternative imported surface supply would own the unpumped water. However, the provisions do not identify specifically who owns the water.

Under the management plan for the theoretical model, the Department--because it would finance the alternative supply--would obtain assurance, through agreements, that it would either be the owner of the unpumped water or have a right to cut surface deliveries by an amount equal to that stored.

Judicial Authority

Until recently, many legal rights necessary to the establishment of a ground water storage program were not at all well defined. The California Supreme Court decision in The City of Los Angeles v. City of San Fernando and First Appellate District decision in Niles Sand and Gravel Company, Inc. v. Alameda County Water District addressed the relevant issues and ruled in favor of giving public agencies certain rights in ground water basins and the authority necessary to implement a ground water storage program.

The decision in the San Fernando case resolved a suit filed by the City of Los Angeles to quiet its title and obtain a declaration of its prior rights to the water in the San Fernando Basin. The city had made separate claims to (1) native ground water of the San Fernando Basin, and (2) ground water derived from imported water.

It asserted a "pueblo right", a right ascribed by Spanish and Mexican law, to the native water of the San Fernando Basin. The Supreme Court upheld this

THE UNLINED FLOOR of the Los Angeles River channel permits surface flows to percolate and rising water to come to the surface. This is a view of the channel in the River Narrows where rising water can flow out of the basin.

claim after reviewing the history of the pueblo right and the prior cases based upon the right.

Of more significance for this bulletin is the court's holding that Los Angeles has a right to recapture the waters that it has imported from the Owens Valley and other sources and placed, directly or indirectly, in the San Fernando Basin. The court also held that other overlying cities have similar right to recapture waters imported from any source that they place in a ground water basin. The opinion greatly clarified and confirmed the right to use ground water storage capacity for storage of imported waters.

In the other case, the replenishment program of the Alameda County Water District, which used in part SWP water, had raised the water table level in the vicinity of the Niles Sand and Gravel Company's excavations and caused some flooding. The gravel company was pumping the water that flooded its excavated areas and was discharging that water into San Francisco Bay. However, the gravel pits had historically held local water supplies, and the ground water level created by the Alameda County Water District's replenishment program was below the historic level.

The court held that the water district has a right to store water in natural underground storage space and to prevent the gravel company from taking the stored water, even though the water district was not contemplating recapturing the stored water.

Neither case addresses all the various rights and authorities of public agencies. The San Fernando case reflects that basin's long pueblo right litigation. The Niles case involved a land use permit that prohibited the waste of water. Nonetheless, reliance on these recent rulings is clearly justified.

The Supreme Court decision in the San Fernando case is recent (May 12, 1975) and the opinion was unanimous. The policy is clear, favoring rational use of ground water resources. The court emphasized its constitutional duty "...to protect the parties' rights in a manner that would minimize waste and maximize beneficial use of the water...". An intent to protect the rights of public agencies to use natural underground basins is expressed in the court's ruling that gave the right to recapture returns from delivered imported water priority over overlying and appropriative rights.

The Appellate Court in the Niles case supported the same policy and intent, and the State and United States Supreme Courts refused to hear any appeal.

Right to Use Storage Capacity

Together, the cases recognize the right of a public agency (1) to store water in underground storage space by placing water in that space either directly by spreading or indirectly through percolation after use by consumers and (2) to recapture imported stored water.

The court in the San Fernando case rejected the trial court's restrictions on Los Angeles' recharge program and stated, "[P]laintiff [Los Angeles] is entitled to use the San Fernando Basin for temporary storage of water by means of artificial recharge and subsequent recapture." It cited Water Code Section 7075, which allows the transportation of foreign water in a stream with excess capacity where that space is not necessary to transport local water. The court held that the section applies to the addition and withdrawal of water in a ground water basin, thereby eliminating the major legal impediments to the use of unused storage capacity in a ground water basin for storage of SWP water.

Also, the opinion swept aside the question of whether prior intent to recapture is always necessary. The court reasoned that "the parties' respective rights to the return flow derived from

delivered imported water in this case [and] do not depend on plaintiff's intent prior to importation."

The court in the Niles case applied the correlative rights doctrine of water law, which specifies that, as between owners of land overlying a ground water supply, the rights of each to the water are limited, in correlation with those of others, to the reasonable use of the water when it is insufficient to meet the needs of all. The court called the obligation of the parties a "servitude" and recognized that it is a "public" servitude because the right to enforce the obligation rests in a public agency. In this case, the court held that an overlying owner is prevented from using an unreasonable portion of the underlying ground water and may be prevented from interfering with public ground water storage programs.

The court based its decision on Article XIV, Section 3 (now Article X, Section 2) of the California Constitution, which declares that the general welfare of the citizenry requires the beneficial and reasonable use of the State's water resources, and cited the company's waste of the water. It held that the water district's actions were a valid exercise of its police powers under this section.

The result in that case was that the overlying owner (a gravel company) had no right to interfere with the water district's storage operations in a natural basin or to obtain compensation for damages caused by such operations.

The policy and intent in both cases are clear: to permit public agencies to store water underground so they can make the optimum use of the waters of the State.

Right to Recapture

The public agency which imports foreign waters for storage in a basin must be assured that it has a right to retrieve the stored water when needed.

WATER HAS BEEN IMPORTED from the Owens Valley to the San Fernando Basin since 1913. Shown here are the two Los Angeles Aqueducts as they enter the San Fernando Valley. The Van Norman Complex of reservoirs is in the background.

This was not an issue in the Niles case, because the water district's water management plan specifically permitted extractions subject to a tax. This led the court to conclude that the district owned the water as trustee for the overlying owners who were permitted under the plan to make extractions.

Specifically on point is the San Fernando case, which recognized the right of an agency to recapture imported water that it had placed in the basin. Moreover, that right was given priority over overlying and appropriative rights to water from the basin.

The court explained the rationale for the recapture right in the following language: "The purpose of giving the right to recapture returns from delivered

imported water priority over overlying rights and rights based on appropriations of the native ground water supply is to credit the importer with the fruits of his expenditures and endeavors in bringing into the basin water that would not otherwise be there."

In discussing the recapture right, the court cited Water Code Section 7075, upon which it based the storage right, and found that the recapture right "does not necessarily attach to the corpus of water physically traceable to peculiar deliveries but is a right to take from the commingled supply an amount equivalent to the augmentation contributed by the return flow from those deliveries."

Protection Right

Both cases recognized the right of a public entity to protect its ground water investment.

The court in the Niles case granted the water district monetary damages for the ground water it had injected and the gravel company had pumped out of the gravel pit and wasted into San Francisco Bay. The court also granted an injunction against further pumping from the gravel pit.

The Supreme Court in the San Fernando case protected the importers by limiting extractions of the imported water to the extent of the amounts stored by each public agency.

Storage Priorities

The court in the San Fernando case stated, "No necessity is shown for interfering with this right to use the basin for storage, for there does not appear to be any shortage of underground storage space in relation to the demand therefor." This raises the question of who has priority to fill unused storage space in the basin.

In neither case were storage priorities discussed specifically. Even if one assumes that an overlying agency would have a prior right to use storage space, that right is not unlimited. Under both cases, in an application of the correlative rights doctrine, the overlying owner or local agency would be entitled to use only that reasonable amount of storage capacity necessary to supply its needs.

The theoretical model is based on the assumption that there is excess storage capacity in the San Fernando Basin. Many ground water basins physically contain more unused storage capacity than their overlying users require for regulation and storage of existing supplies. A portion of this unused storage capacity is what the Department intends to use for the theoretical model. The issue of storage priorities should not arise as long as natural percolation and new storage programs do not augment the supply of ground water to a point where a surplus occurs.

Needed Agreements

Under the management plan developed by the advisory committee for the theoretical model in the San Fernando Basin, two major interrelated agreements are proposed: (1) one between the Department and MWD (State agreement) and (2) one among the Department, MWD, MWD's affected member public agencies overlying the basin (the Cities of Burbank, Glendale, Los Angeles, and San Fernando) and the Los Angeles County Flood Control District (local agreement). These agreements would formalize the operating procedure that has been described in Chapter IV, would create an operating committee and provide guidelines for it, and would resolve various issues surrounding the program.*

The State agreement would describe the methods, procedures, and responsibilities

*At presstime, negotiations on these agreements were still under way. The agreements might also be used for a demonstration project in the basin, which could later be incorporated into the SWP as an additional conservation facility.

for delivering SWP water to MWD and for recapturing it and the provisions for payment.

The local agreement would provide the mechanisms for getting the water in the ground, either directly by spreading or indirectly by exchange, and for recapturing the water. The mechanisms for storage or recapture would have to be coordinated with all the parties who spread water or have rights to produce ground water. Under the management plan for the theoretical model, this coordination would be done through an operating committee. The local agreement would also provide the guidelines and criteria that would govern the activities of the operating committee to ensure that water quality would be maintained, damage from high water levels prevented, and losses of SWP ground water minimized.

Furthermore, for the Department to adopt and implement SWP ground water storage, it would require the assurance, through the local agreement, of reasonable minimum quantities of firm capacity for storage and recapture.

Under the management plan for the theoretical model, additional agreements would be entered into as necessary to provide for construction of facilities to transport water from MWD's system to the spreading grounds.

CHAPTER VI. ECONOMIC AND FINANCIAL EFFECTS

For the economic analysis of the theoretical model, the assumption was made that ground water storage would be classified as an additional SWP conservation facility and that repayment provisions of existing water supply contracts would be used. Therefore, reimbursement to the State would be through the Delta Water Charge. Computations are based on the operational schedule in Table 6.

Because the concept of ground water storage is being considered as one of the alternatives for developing future supplies for the SWP, a limited evaluation of the long-term (through the life of the SWP) operation of the theoretical model was included. The schedule for this operation and the discussion appear at the end of this chapter.

No attempt was made to conduct a cost analysis of concurrent operation of a series of SWP ground water storage programs such as is being contemplated as part of the SWP future supply studies. To conduct a complete cost analysis would require that, first, a decision be made as to which alternative measures for developing additional SWP supplies will be included and, second, identification be made of what additional facilities will be needed for all the ground water storage programs (if they are among the alternatives recommended). The cost of the additional facilities for all ground water storage programs could be substantial.

Estimating Costs and Savings

These estimates of costs and savings are based (1) on those in Department of Water Resources Bulletin 132-76; (2) on the 1976 incremental costs of pumping ground water, treating water, and operating facilities within the San Fernando Basin; and (3) on 1976 capital costs for construction.* They do not allow for future cost escalation.

JOSEPH JENSEN FILTRATION PLANT, at the northern entrance to the San Fernando Valley, treats SWP water before it is delivered to MWD's member agencies. All water for indirect storage would pass through this plant.

*Cost of constructing wells and pipelines that might be needed for recapturing water are not included; to do so would require new economic and net energy analyses. Because this study is for a theoretical model only, the additional expense of making the new analyses was not thought to be justified.

Storage Costs

The costs for the theoretical model during the storage cycles of both combinations 1 and 2 are summarized in Table 7.

Water Supply. The cost of delivering SWP water to Castaic Lake is identified as the cost of the water supply. For the theoretical model, the assumption was made that the State would purchase MWD entitlement water for its water supply. The purchase price would consist of the Delta Water Charge and the variable OMP&R component of the Transportation Charge (see box) that MWD would pay for this amount of water under its SWP water supply contract. The estimates of these costs for the life of the theoretical model were based on those shown in Appendix B of Bulletin 132-76.

Direct and Indirect Storage. From Castaic Lake, the SWP water to be stored would be transported through MWD facilities to the spreading basins for the direct storage method or to the Joseph Jensen Filtration Plant and then to the point of exchange for the indirect storage method. MWD has indicated that it would not charge for the use of its transportation facilities because they form a gravity system and no additional cost would be incurred.

The only costs involved for storing water by the direct method would be (1) an operation and maintenance cost incurred for spreading, estimated to be $3 per 1 233 cubic metres (1 acre-foot), and (2) a construction cost for connecting MWD facilities to the spreading grounds.

Water stored by the indirect method would be treated at MWD's Joseph Jensen Filtration Plant for delivery to the local agencies. The estimated cost was $3 per 1 233 cubic metres.

Storage Savings

During the indirect storage portion of the two combinations, savings would result from the reduced use of ground water. This would reduce the amount of power required for pumping ground water and the amount of ground water treated before delivery. These savings for the theoretical model during storage cycles of both combinations are summarized in Table 7.

Reduced Pumping. The estimated savings for ground water pumping used for this

TABLE 7 COSTS AND SAVINGS DURING STORAGE
In $1,000

Storage years	Costs				Savings		
	Water supply	Direct storage*	Indirect storage	Totals	Reduced pumping	Reduced treatment	Totals
			COMBINATION 1				
1976-81	4,328	765	195	5,288	1,141	130	1,271
1988-92	18,939	765	195	19,899	1,152	130	1,282
Totals	23,267	1,530	390	25,187	2,293	260	2,553
			COMBINATION 2				
1976-82	4,169	330	630	5,129	3,572	420	3,992
1988-93	19,661	330	630	20,621	3,575	420	3,995
Totals	23,830	660	1,260	25,750	7,147	840	7,987

*Does not include initial cost of constructing connections from MWD facilities to the spreading grounds. Estimated construction cost in 1976 for combination 1 (primarily direct storage) is $1,500,000; for combination 2 (primarily indirect storage), $335,000.

HOW IS THE STATE WATER PROJECT PAID FOR?

All facilities of the SWP are basically designed either to store water (known as "project conservation facilities") or to convey water to the contractors ("project transportation facilities"). The conservation facilities benefit all contractors; therefore, all contractors pay for them in proportion to their annual entitlements. The transportation facilities are for the benefit of specific contractors and the costs are paid accordingly.

The mechanism for paying the conservation costs is known as the Delta Water Charge. That for transportation is the Transportation Charge.

The Delta Water Charge is assessed on each 1 233 cubic metres (1 acre-foot) of water the contractors are entitled to receive as shown in Table A of their respective contracts. The charge is computed so as to return to the State all appropriate reimbursable costs of the SWP conservation facilities. The charge consists of:

1. The capital component, designed to reimburse the conservation capital expenditures and is paid according to each contractor's Table A entitlement, regardless of the amount delivered.
2. The minimum component, designed to reimburse the operation, maintenance, power, and replacement (OMP&R) costs of the conservation facilities and is also paid regardless of the amount of water delivered; and
3. The variable OMP&R component, also designed to reimburse the OMP&R costs of the conservation facilities and paid according to the amount of water delivered. (This component is not being charged up to the time of this report because current conservation facility costs do not vary with the amount of water delivered to the SWP contractors.)

The Transportation Charge is levied to recover costs of constructing, operating, and maintaining the SWP transportation facilities. Each SWP contractor pays an allocated share of those transportation costs incurred in the delivery of SWP water. The Transportation Charge consists of:

1. The capital cost component, calculated to return those capital costs of SWP transportation facilities necessary to deliver water to the contractors and paid by each contractor according to the proportionate use of each facility under maximum annual Table A amounts.
2. The minimum OMP&R component, designed to return OMP&R costs associated with the transportation facilities necessary to deliver water to the contractors irrespective of the amount of SWP water actually delivered; and
3. The variable OMP&R component, designed to return those OMP&R costs associated with the transportation facilities dependent on and varying with the amount of SWP water actually delivered to the contractor.

analysis were based on actual power costs from the Cities of Los Angeles, Burbank, and Glendale. An assumption was made that participation during the indirect storage portion of the model would be 70 percent by Los Angeles and 15 percent each for Burbank and Glendale. The average applicable power cost saving was estimated to be $19 per 1 233 cubic metres, based on a basin average pumping and boosting lift of 91 metres (300 feet). To estimate the pumping lifts, studies of the ground water basin were conducted by the City of Los Angeles on its computer model for each of the two storage combinations.

<u>Reduced Treatment.</u> Obviously, ground water not pumped would not require treatment. This would result in an estimated ground water treatment saving of $2 per 1 233 cubic metres for water left in the basin by cities in lieu of SWP deliveries on the surface.

Recapture Costs

For this cost analysis, the assumption was made that recapture option 1 (described in Chapter IV) would be used.

Therefore, at the time of recapture, the local agencies would be requested to pump SWP ground water from the basin, which they would use in place of treated surface water that would normally have been delivered by MWD. The SWP entitlement deliveries to MWD at Castaic Lake would be reduced by an equal amount. Nonetheless, MWD would pay the variable OMP&R component of the Transportation Charge for this water just as if it had been delivered on the surface.

The costs for the following items would be incurred during the recapture cycles (Table 8):

1. Power to pump the SWP ground water and boost it to the distribution systems of the local agencies;

2. Operation and maintenance (O&M) above that required for the normal pumping operations of the cities; and

3. Treatment of the SWP ground water.

Also, additional wells and pipelines may be needed for recapturing water. The cost of these additional facilities is not included in the analysis given here. The power cost for recapture was estimated in the same manner as the power costs for indirect storage.

The additional O&M cost that the cities would incur was estimated to be $2.20 per 1 233 cubic metres (1 acre-foot). This is an estimated average furnished by the cities.

Treatment of SWP ground water was estimated to be $2 per 1 233 cubic metres.

Recapture Saving

Water normally delivered to local agencies from surface sources is treated at MWD's filtration plant and that cost is charged to the cities. But because water extracted from the ground would not receive this treatment, an estimated 1976 saving of $3 per 1 233 cubic metres would be realized during recapture periods (Table 8).

Additional Savings

Cities that pump their local water supply from the basin would also benefit

TABLE 8. COSTS AND SAVINGS DURING RECAPTURE
In $1,000

Recapture years	Costs* Pumping and boosting	Additional O&M	SWP ground water treatment	Totals	Savings MWD treatment
		COMBINATION 1			
1983-87	5,473	660	600	6,733	900
1994-98	5,431	660	600	6,691	900
Totals	10,904	1,320	1,200	13,424	1,800
		COMBINATION 2			
1983-87	5,439	660	600	6,699	900
1994-98	5,393	660	600	6,653	900
Totals	10,832	1,320	1,200	13,352	1,800

*Does not include cost of constructing wells and pipelines that might be needed.

from higher ground water tables while the SWP ground water was stored in the basin. Reducing the pumping lift would reduce the power costs.

The City of Los Angeles' computer model of the basin indicates that the ground water levels would rise approximately 12 metres (40 feet) if 394.7 cubic hectometres (320,000 acre-feet) of additional water were stored in the basin and a safe yield operation were continued. This would mean an annual power saving of 6.5 million kWh or approximately $240,000 for the cities. Therefore, during the storage and recapture schedules used for the theoretical model, total savings for the cities would be an estimated $2.1 million. These savings are not shown in any of the tables.

Allocating Costs and Savings

For this analysis of operation of the theoretical model under the management plan given in Chapter IV, the allocation of costs and savings (i.e., which agencies would pay for the costs incurred and/or benefit from the savings realized) was developed by the advisory committee.

Storage

Under the management plan for the theoretical model, MWD would increase its Table A entitlement to include water for ground water storage. MWD would be billed a Delta Water Charge and Transportation Charge (variable OMP&R component) for this water, because it would be transported through the SWP system as MWD entitlement water.

When the water to be stored entered the basin, by either the direct or indirect method, the Department would buy from MWD the portion designated as water to be stored by paying the Delta Water Charge and the variable OMP&R component of the Transportation Charge associated with such water; thus, MWD's costs for delivering the water to the basin would be canceled, but the State would actually have incurred these costs in delivering the water.

If the water were stored by the direct method, the State would pay the spreading cost and the construction costs for the required connections.

If the water were stored by the indirect method, three other items would have to be included: (1) treatment costs at MWD's filtration plant; (2) ground water pumping and boosting power savings; and (3) ground water treatment savings. The cities would pay the MWD treatment costs (item 1) when they received the water. The cities and the State would share the savings in ground water pumping and boosting on a 50-50 basis (item 2). The amount of power savings would be determined by the cities; they would then pay one-half of the savings to the State. The savings in ground water treatment (item 3) would stay with the cities.

Table 9 summarizes the allocation of costs and savings for the direct and indirect storage methods.

Recapture

Under the management plan for the theoretical model, the SWP ground water at time of recapture would be regarded as MWD entitlement water delivered to Castaic Lake. Therefore, MWD would be billed a Delta Water Charge and Transportation Charge (variable OMP&R component) for that amount of water. This is not regarded as a cost chargeable to the ground water storage program, because it would be incurred whether or not the program was in effect.

In making this economic analysis, the assumption was that the recapture would be accomplished by means of option 1, which means that each of the cities now pumping from the basin would pump SWP ground water in lieu of taking delivery of an equal amount of SWP surface water. Thus four additional

items of cost and savings would apply: (1) pumping and boosting power costs to recapture the SWP ground water, (2) additional O&M costs associated with the ground water pumping, (3) ground water treatment costs, and (4) savings of MWD's treatment costs.

The State would pay for pumping the water from the basin and boosting it to the distribution system of the cities (item 1) and the additional O&M costs associated with the ground water pumping (item 2). The cities would pay the ground water treatment costs (item 3) and would benefit from the savings of the MWD treatment costs (item 4). Table 10 summarizes the allocation of costs and savings for recapture.

Economic Effects of Model

The total costs for the storage and recapture cycles for the theoretical model were allocated as described above. Using the costs and savings given in Tables 7 and 8 and the allocations in

TABLE 9
ALLOCATING COSTS AND SAVINGS FOR STORAGE

Agency	Direct storage		Indirect storage	
	Costs	Savings	Costs	Savings
State	•Water supply: Delta Water Charge and Transportation Charge (Variable OMP&R) •Spreading •Construction of connections		•Water supply: Delta Water Charge and Transportation Charge (Variable OMP&R)	•1/2 ground water pumping and boosting
MWD*				
Cities			•MWD treatment	•1/2 ground water pumping and boosting •Ground water treatment
LACFCD				

*The Delta Water Charge and Transportation Charge (variable OMP&R component) paid to the State by MWD at time of delivery to Castaic Lake is reimbursed by State at time of storage.

TABLE 10
ALLOCATING COSTS AND SAVINGS FOR RECAPTURE

Agency	Costs	Savings
State	•Ground water pumping and boosting •Additional O&M for ground water pumping	
MWD		
Cities	•Ground water treatment	•MWD treatment

Tables 9 and 10, Table 11 was developed to show the net effect of the theoretical model.

As has been pointed out, MWD's costs and savings are not included in Table 11, because (1) those incurred at the time of storage would be canceled out, and (2) those incurred at the time of recapture would be the same whether the water is delivered from SWP surface facilities or pumped from the basin. Nonetheless, MWD would benefit, as would all 31 SWP water service contractors, because a dry-period yield of 59.2 cubic hectometres (48,000 acre-feet) would be developed for the SWP for the life of the theoretical model. However, the State would not actually incur a cost for pumping from the Delta at time of recapture; therefore, the variable component of the Transportation Charge paid by MWD would be credited to the Delta Water Charge. This credit is estimated to be $26.4 million. Therefore, the net costs to the State for both combinations shown in Table 11 would be further reduced by $26.4 million.

Combination 2 (primarily indirect storage) results in a smaller cost to the State and a larger savings for the cities, because the larger amount of water stored by the indirect method would reduce the amount of pumping in the basin during the storage years.

The analysis also indicated that the operation of the theoretical model would represent a further benefit to the

TABLE 11
ECONOMIC EFFECTS OF THEORETICAL MODEL[a]
In $1,000

Period	State		Cities	
	Costs	Savings[b]	Costs	Savings
		COMBINATION 1		
1976-81	6,593[c]	571	195	701
1983-87	6,133	--	600	900
1988-92	19,704	576	195	706
1994-98	6,091	--	600	900
Totals	38,521	1,147	1,590	3,207
Net cost	37,374		Net savings	1,617
		COMBINATION 2		
1976-82	4,834[c]	1,786	630	2,206
1983-87	6,099	--	600	900
1988-93	19,991	1,788	630	2,208
1994-98	6,053	--	600	900
Totals	36,977	3,574	2,460	6,214
Net cost	33,403		Net savings	3,754

a MWD's costs and savings are not shown because they cancel each other.

b Does not include $26.4 million for variable OMP&R component of Transportation Charge paid by MWD to the State at time of recapture under either combination.

c Includes cost of initial construction: under combination 1, this is $1,500,000, and under combination 2, $335,000.

cities overlying the basin under either combination. Under combination 1 (primarily direct storage), the cities would not only receive an operating saving of \$1.6 million, but also a saving of \$2.1 million because of the higher ground water table, for a total savings of \$3.7 million. When discounted to 1976 present worth at an interest rate of 4.462 percent (current interest rate for the SWP), this amounts to \$2.5 million. Combination 2, which stores a much larger amount by the indirect method, produces savings of \$5.9 million (operating saving of \$3.8 million plus \$2.1 million because of a higher ground water table) and discounts to \$3.9 million for the assumed life of the model (1976-98).

State Financing

Under the management plan for the theoretical model, the Department would finance the construction portion with funds that are available to it for construction of the State Water Resources Development System.

The Department has previously interpreted appropriations for construction to include operating costs for initial filling of SWP surface reservoirs. Thus, the Department may use the "construction" funds to pay for the initial filling of the ground water storage space available for the theoretical model. The storage costs incurred after initial recharge and recapture would be classified as operation costs.

Because the San Fernando Ground Water Basin would be considered an additional conservation facility of the SWP, reimbursement would be through the Delta Water Charge, payable by all SWP contractors.

For the theoretical model, the first year that the Delta Water Charge would be recalculated is 1977. For the recalculation, the net costs during the storage and recapture cycles, as shown in Table 11, would be used plus a credit for the \$26.4 million variable OMP&R component of the Transportation Charge paid by MWD at time of recapture.

Under the management plan for the theoretical model, combination 1 (primarily direct storage) would increase the Delta Water Rate by 6¢ per 1 233 cubic metres (1 acre-foot). Combination 2 (primarily indirect storage) would increase it by 1¢ per 1 233 cubic metres. This rate increase would apply to each 1 233 cubic metres of entitlement water from 1977 through 2035 (currently assumed to be the end of the SWP repayment period). However, the yield from the model would be only during the time covered by the operational schedule--1976-98.

Long-term Operation

In addition to the short-term operation described above, a partial evaluation was made of the long-term financial effect of operation of the theoretical model, because storing SWP water in the San Fernando Basin is being considered as one of the alternatives for developing future supplies for the SWP. The schedule for extended operation would be for 1979 through 2035.

The assumption was made that, during the long-term period, the Sacramento-San Joaquin Delta would experience several wet and dry cycles.

The starting year--1979--was assumed to be a year with above normal rainfall following a dry cycle, just as 1935 had been; therefore, the hydrologic conditions of 1935 were used for 1979 (Table 12). For 1980 through 2015, the pattern of wet and dry years of 1936 through 1971 was followed. For 2016 through 2035, the pattern of 1922 through 1941 was followed.

The simulated operation (Tables 13 and 14) included the following:

—Water was stored in wet and above normal years and recaptured in below normal, dry, and critically dry years.

TABLE 12
HISTORIC HYDROLOGIC CLASSIFICATIONS IN THE SACRAMENTO-SAN JOAQUIN DELTA

Year	Hydrologic classification*	Year	Hydrologic classification*
1922	above normal	1947	dry
1923	below normal	1948	above normal
1924	critically dry	1949	dry
1925	above normal	1950	below normal
1926	dry	1951	wet
1927	wet	1952	wet
1928	above normal	1953	wet
1929	critically dry	1954	above normal
1930	dry	1955	dry
1931	critically dry	1956	wet
1932	dry	1957	below normal
1933	critically dry	1958	wet
1934	critically dry	1959	dry
1935	above normal	1960	below normal
1936	above normal	1961	dry
1937	below normal	1962	below normal
1938	wet	1963	wet
1939	critically dry	1964	dry
1940	above normal	1965	wet
1941	wet	1966	below normal
1942	wet	1967	wet
1943	wet	1968	below normal
1944	dry	1969	wet
1945	below normal	1970	wet
1946	above normal	1971	wet

*Hydrologic classification is based on a 4-river index, which is an estimated unimpaired runoff for a water year for: (1) Sacramento River above Bend Bridge near Red Bluff, (2) Feather River total inflow to Lake Oroville, (3) Yuba River at Smartville, and (4) American River total inflow to Folsom Lake. Classifications are:

critically dry $\leq$	12.6 thousand cubic hectometres (10.2 million acre-feet) unless preceded by a critically dry year. In that case, $\leq$ 15.4 thousand cubic hectometres (12.5 million acre-feet).
dry =	between 12.6 thousand and 15.4 thousand cubic hectometres unless preceded by a critically dry year. In that case, between 15.4 thousand and 19.4 thousand cubic hectometres (15.7 million acre-feet).
below normal =	between 15.4 thousand and 19.4 thousand cubic hectometres, if not preceded by a critically dry year.
above normal =	between 19.4 thousand and 24.2 thousand cubic hectometres (19.6 million acre-feet).
wet $\geq$	24.2 thousand cubic hectometres unless preceded by a critically dry year. In that case, $\geq$ 27.8 thousand cubic hectometres (22.5 million acre-feet).

TABLE 13
LONG-TERM OPERATIONAL SCHEDULE
FOR
COMBINATION I (Primarily Direct Storage)

Operational year (Calendar year)	In cubic hectometres				In thousand acre-feet			
	Direct	Indirect	Total	Cumulative	Direct	Indirect	Total	Cumulative
1979	41.9	9.9	51.8	51.8	34	8	42	42
1980	41.9	9.9	51.8	103.6	34	8	42	84
1981	*Recapture*		-29.6	74.0	*Recapture*		-24	60
1982	53.0	13.6	66.6	140.6	43	11	54	114
1983	*Recapture*		-74.0	66.6	*Recapture*		-60	54
1984	41.9	9.9	51.8	118.4	34	8	42	96
1985	53.0	13.6	66.6	185.0	43	11	54	150
1986	53.0	13.6	66.6	251.6	43	11	54	204
1987	53.0	13.6	66.6	318.2	43	11	54	258
1988	*Recapture*		-51.8	266.4	*Recapture*		-42	216
1989	*Recapture*		-29.6	236.8	*Recapture*		-24	192
1990	41.9	9.9	51.8	288.6	34	8	42	234
1991	*Recapture*		-51.8	236.8	*Recapture*		-42	192
1992	41.9	9.9	51.8	288.6	34	8	42	234
1993	*Recapture*		-51.8	236.8	*Recapture*		-42	192
1994	*Recapture*		-29.6	207.2	*Recapture*		-24	168
1995	53.0	13.6	66.6	273.8	43	11	54	222
1996	53.0	13.6	66.6	340.4	43	11	54	276
1997	43.2	11.1	54.3	394.7	35	9	44	320
1998	*No action*		0	394.7	*No action*		0	320
1999	*Recapture*		-51.8	342.9	*Recapture*		-42	278
2000	41.9	9.9	51.8	394.7	34	8	42	320
2001	*Recapture*		-29.6	365.1	*Recapture*		-24	296
2002	23.4	6.2	29.6	394.7	19	5	24	320
2003	*Recapture*		-51.8	342.9	*Recapture*		-42	278
2004	*Recapture*		-29.6	313.3	*Recapture*		-24	254
2005	*Recapture*		-51.8	261.5	*Recapture*		-42	212
2006	*Recapture*		-29.6	231.9	*Recapture*		-24	188
2007	53.0	13.6	66.6	298.5	43	11	54	242
2008	*Recapture*		-51.8	246.7	*Recapture*		-42	200
2009	53.0	13.6	66.6	313.3	43	11	54	254
2010	*Recapture*		-29.6	283.7	*Recapture*		-24	230
2011	53.0	13.6	66.6	350.3	43	11	54	284
2012	*Recapture*		-29.6	320.7	*Recapture*		-24	260
2013	53.0	13.6	66.6	387.3	43	11	54	314
2014	6.2	1.2	7.4	394.7	5	1	6	320
2015	*No action*		0	394.7	*No action*		0	320
2016	*No action*		0	394.7	*No action*		0	320
2017	*Recapture*		-29.6	365.1	*Recapture*		-24	296
2018	*Recapture*		-74.0	291.1	*Recapture*		-60	236
2019	41.9	9.9	51.8	342.9	34	8	42	278
2020	*Recapture*		-51.8	291.1	*Recapture*		-42	236
2021	53.0	13.6	66.6	357.7	43	11	54	290
2022	29.6	7.4	37.0	394.7	24	6	30	320
2023	*Recapture*		-74.0	320.7	*Recapture*		-60	260
2024	*Recapture*		-51.8	268.9	*Recapture*		-42	218
2025	*Recapture*		-74.0	194.9	*Recapture*		-60	158
2026	*Recapture*		-51.8	143.1	*Recapture*		-42	116
2027	*Recapture*		-74.0	69.1	*Recapture*		-60	56
2028	*Recapture*		-69.1	0	*Recapture*		-56	0
2029	41.9	9.9	51.8	51.8	34	8	42	42
2030	41.9	9.9	51.8	103.6	34	8	42	84
2031	*Recapture*		-29.6	74.0	*Recapture*		-24	60
2032	53.0	13.6	66.6	140.6	43	11	54	114
2033	*Recapture*		-74.0	66.6	*Recapture*		-60	54
2034	41.9	9.9	51.8	118.4	34	8	42	96
2035	53.0	13.6	66.6	185.0	43	11	54	150

TABLE 14
LONG-TERM OPERATIONAL SCHEDULE
FOR
COMBINATION 2 (Primarily Indirect Storage)

Operational year (Calendar year)	Cubic hectometres				Thousand acre-feet			
	Direct	Indirect	Total	Cumulative	Direct	Indirect	Total	Cumulative
1979	18.5	33.3	51.8	51.8	15	27	42	42
1980	18.5	33.3	51.8	103.6	15	27	42	84
1981	*Recapture*		-29.6	74.0	*Recapture*		-24	60
1982	23.4	43.2	66.6	140.6	19	35	54	114
1983	*Recapture*		-74.0	66.6	*Recapture*		-60	54
1984	18.5	33.3	51.8	118.4	15	27	42	96
1985	23.4	43.2	66.6	185.0	19	35	54	150
1986	23.4	43.2	66.6	251.6	19	35	54	204
1987	23.4	43.2	66.6	318.2	19	35	54	258
1988	*Recapture*		-51.8	266.4	*Recapture*		-42	216
1989	*Recapture*		-29.6	236.8	*Recapture*		-24	192
1990	18.5	33.3	51.8	288.6	15	27	42	234
1991	*Recapture*		-51.8	236.8	*Recapture*		-42	192
1992	18.5	33.3	51.8	288.6	15	27	42	234
1993	*Recapture*		-51.8	236.8	*Recapture*		-42	192
1994	*Recapture*		-29.6	207.2	*Recapture*		-24	168
1995	23.4	43.2	66.6	273.8	19	35	54	222
1996	23.4	43.2	66.6	340.4	19	35	54	276
1997	18.5	35.8	54.3	394.7	15	29	44	320
1998	*No action*		0	394.7	*No action*		0	320
1999	*Recapture*		-51.8	342.9	*Recapture*		-42	278
2000	18.5	33.3	51.8	394.7	15	27	42	320
2001	*Recapture*		-29.6	365.1	*Recapture*		-24	296
2002	9.9	19.7	29.6	394.7	8	16	24	320
2003	*Recapture*		-51.8	342.9	*Recapture*		-42	278
2004	*Recapture*		-29.6	313.3	*Recapture*		-24	254
2005	*Recapture*		-51.8	261.5	*Recapture*		-42	212
2006	*Recapture*		-29.6	231.9	*Recapture*		-24	188
2007	23.4	43.2	66.6	298.5	19	35	54	242
2008	*Recapture*		-51.8	246.7	*Recapture*		-42	200
2009	23.4	43.2	66.6	313.3	19	35	54	254
2010	*Recapture*		-29.6	283.7	*Recapture*		-24	230
2011	23.4	43.2	66.6	350.3	19	35	54	284
2012	*Recapture*		-29.6	320.7	*Recapture*		-24	260
2013	23.4	43.2	66.6	387.3	19	35	54	314
2014	2.5	4.9	7.4	394.7	2	4	6	320
2015	*No action*		0	394.7	*No action*		0	320
2016	*No action*		0	394.7	*No action*		0	320
2017	*Recapture*		-29.6	365.1	*Recapture*		-24	296
2018	*Recapture*		-74.0	291.1	*Recapture*		-60	236
2019	18.5	33.3	51.8	342.9	15	27	42	278
2020	*Recapture*		-51.8	291.1	*Recapture*		-42	236
2021	23.4	43.2	66.6	357.7	19	35	54	290
2022	12.3	24.7	37.0	394.7	10	20	30	320
2023	*Recapture*		-74.0	320.7	*Recapture*		-60	260
2024	*Recapture*		-51.8	268.9	*Recapture*		-42	218
2025	*Recapture*		-74.0	194.9	*Recapture*		-60	158
2026	*Recapture*		-51.8	143.1	*Recapture*		-42	116
2027	*Recapture*		-74.0	69.1	*Recapture*		-60	56
2028	*Recapture*		-69.1	0	*Recapture*		-56	0
2029	18.5	33.3	51.8	51.8	15	27	42	42
2030	18.5	33.3	51.8	103.6	15	27	42	84
2031	*Recapture*		-29.6	74	*Recapture*		-24	60
2032	23.4	43.2	66.6	140.6	19	35	54	114
2033	*Recapture*		-74.0	66.6	*Recapture*		-60	54
2034	18.5	33.3	51.8	118.4	15	27	42	96
2035	23.4	43.2	66.6	185.0	19	35	54	150

--Amount of storage and recapture varied, depending on the wetness or dryness of the historical years.

--Maximum basin storage at any one time was 394.7 cubic hectometres (320,000 acre-feet).

--Maximum annual storage was 66.6 cubic hectometres (54,000 acre-feet) and maximum annual recapture was 74.0 cubic hectometres (60,000 acre-feet).

--Amount recaptured never exceeded amount of SWP water stored.

--SWP water for ground water storage would come from increased MWD entitlement deliveries.

--Combination 1 would store 80 percent by the direct method and 20 percent by the indirect method, and combination 2 would store 35 percent directly and 65 percent indirectly.

During the life of this extended schedule, 1 510 cubic hectometres (1,226,000 acre-feet) of SWP water would be transported to the basin for storage, and 1 330 cubic hectometres (1,076,000 acre-feet) would be recaptured from the basin. The remaining 185.0 cubic hectometres (150,000 acre-feet) would be left in storage in 2035.

The costs and savings for this schedule, shown in Table 15, were analyzed in the same manner as described earlier.

The assumption was that the construction costs were the same as those for the theoretical model for the short-term operation. (Not included are the costs of construction of additional wells and pipelines that might be needed for recapturing SWP ground water.)

TABLE 15
COSTS AND SAVINGS DURING LONG-TERM OPERATION
In $1,000

	Combination 1	Combination 2
Storage costs		
Water supply	73,222	73,150
Direct storage	2,946	1,296
Indirect storage	732	2,382
Total	76,900	76,828
Storage savings		
Reduced pumping	4,285	13,954
Reduced treatment	488	1,588
Total	4,773	15,542
Recapture costs		
Pumping and boosting	18,326	18,326
Additional O&M	2,365	2,365
SWP ground water treatment	2,152	2,152
Total	22,843	22,843
Recapture savings		
MWD treatment	3,228	3,228
Increase in Delta Water Charge	16¢*	10¢*

*Cost per 1 233 cubic metres (1 acre-foot)

The costs and savings were allocated to the State and cities as summarized in Tables 9 and 10 with the following net results:

- For combination 1, net cost to the State would be $94.7 million and net savings to the cities, $3 million.
- For combination 2, net cost to the State would be $88.2 million and net savings to the cities, $7.2 million.

The cities would also benefit from the higher ground water table for their normal annual pumping. Each year that 394.7 cubic hectometres (320,000 acre-feet) of additional water is stored within the basin, the cities would realize a saving of approximately $240,000, based on 1976 prices. This was estimated to be $9.3 million over the remaining life of the SWP. Therefore, under combination 1 the total savings to the cities would be $12.3 million, which discounts to $3.8 million. For combination 2, the total savings would be $16.5 million, which discounts to $5.5 million.

In the calculation of the rate to be used for the Delta Water Charge, the costs shown above were included, also credit for the variable OMP&R component of the Transportation Charge paid during recapture. The variable OMP&R credit amounted to $62 million. The resultant increase in the rate for the Delta Water Charge for the years 1979 through 2035 would be: 16¢ per 1 233 cubic metres (1 acre-foot) for combination 1 and 10¢ per 1 233 cubic metres for combination 2.

It should be noted that the costs developed for this long-term ground water operation are applicable for San Fernando Basin only and assume that the repayment would be made through provisions in existing water supply contracts.

Also, the assumption was made that the water for storage in the basin would come from MWD entitlement deliveries. If not, other costs would have to be added for a long-term operation. Among these costs are those for (1) possible enlargement of aqueduct facilities and (2) reallocation of existing aqueduct facilities from transportation to conservation purposes. No estimate has been made for item 1 (or determination made that it would be needed). An estimate has been made of the size of item 2 by applying a "use charge" to the water transported through the aqueduct for storage in the basin. This use charge would reallocate capital and minimum OMP&R costs from transportation to conservation purposes; hence, reimbursement would be through the Delta Water Charge. This use charge could increase the Delta Water Rate by as much as 15¢ per 1 233 cubic metres through year 2035.

COMPARATIVE IMPACTS OF SURFACE AND GROUND WATER RESERVOIRS

Any use of the land or its resources will have a certain effect upon those resources. How much effect will vary from project to project and from locale to locale. Therefore, each project must be evaluated individually.

In general, however, the relative impacts of using a surface reservoir as compared with using a ground water basin for storing SWP water are the following:

Land and Its Inhabitants

A surface reservoir and its appurtenant facilities require considerable surface land, thus disrupting vegetation, wildlife habitat, and possible home and industrial sites over a wide area. They also require extensive construction, which would bring traffic, noise, dust, and other disturbance into the area.

A ground water basin requires no surface land, except for the spreading grounds and well fields. In many cases, the needed spreading grounds and well fields already exist.

Conservation of Water

The conservation of excess flows in the SWP could be started earlier with a ground water basin than with a surface reservoir because of the difference in requirements for land and construction.

Archaeological and Cultural Sites

The greater amount of land required for a surface reservoir means that the possibility of impacting archaeological and cultural sites is much greater than would be the case with a comparable ground water basin.

Construction Costs

Because more construction is required for a surface reservoir and its appurtenances, the cost would be greater than that for a ground water reservoir. In those cases where existing spreading grounds and well fields could be used for operation of the ground water basin, the cost differential would be even greater.

Economy

Because of the greater amount of construction required for a surface reservoir, it would have more impact upon the local economy through the additional jobs provided. However, this impact would be for the construction period only.

Energy Requirements

More energy would be required for the construction of a surface reservoir than for a comparable ground water basin.

However, the operation of a surface reservoir is less energy consumptive than is operation of a comparable ground water basin. To assess the actual energy consumption of either storage method, a number of factors would have to be examined, such as how the reservoir is filled -- by damming a river or by pumping water into it, how much the higher ground water levels created by storing imported water would reduce pumping costs for users of the basin, and how frequently water is stored and recaptured.

Recreation Opportunities

A surface reservoir, by creating a permanent lake, offers the opportunity for recreational activities such as boating, fishing, swimming, and other water-related sports.

The spreading grounds used for ground water storage, although filled with water only intermittently, attract waterfowl and offer the opportunity for nature study.

Instream Uses

A dam constructed on a river interrupts the flow of the river and can have adverse effects on instream use such as fisheries and rafting. A ground water reservoir would not necessarily affect instream use.

CHAPTER VII. ENVIRONMENTAL CONSIDERATIONS

Before an actual storage program could be implemented in any ground water basin, an analysis would have to be made of the possible effects it might have on the environment. To give an indication of what the environmental impact would be in the San Fernando Basin, an assessment was made of the possible local effects of implementing the theoretical model.

This report could, therefore, serve as an initial study for the storing of up to 394.7 cubic hectometres (320,000 acre-feet) of SWP water in the San Fernando Basin. According to the State Guidelines for Implementation of the California Environmental Quality Act of 1970, as amended on September 30, 1976, an initial study is "a preliminary analysis prepared--pursuant to Section 15080 [of the Act] to determine whether an EIR or a Negative Declaration must be prepared."

It is recognized that any change in operating the basin might also have an effect upon the various localities from which water is imported, such as the Colorado River, Mono Basin, Owens Valley, and the Sacramento-San Joaquin Delta. However, an assessment of the effect upon those areas was beyond the scope of this study.

Also to be kept in mind is that many alternatives for supplying future water for the SWP--including ground water storage--are still being studied by the Department; therefore, this report does not look at the other alternatives.

Description

The management plan for the theoretical model calls for its operation according to the schedule given in Table 6. Required for operation of the basin under combination 1 (primarily direct storage) would be the construction of facilities for storing water via route 2, as described in Table 5, and possibly additional wells and distribution facilities for the recapture phase.

Combination 2 (primarily indirect storage) would require the construction of facilities for storing via route 1 (Table 5) and possibly additional wells and distribution facilities.

This report does not consider the effects of operation under the long-term schedule of Tables 13 and 14 nor does it look at the effects of a large-scale ground water storage program throughout the State. It deals only with the theoretical model described in Chapter IV.

Environmental Setting

The San Fernando Valley (geography, climate, precipitation, and demography) is described in Chapter I; geology of the ground water basin is given in Chapter III.

In the early part of this century, the San Fernando Valley consisted mainly of coastal sage scrub vegetation, transitioning into chaparral at higher elevations and on some of the steeper northfacing slopes. The fauna and flora of the vicinity, with few exceptions, were doubtless those which still characterize the remaining natural foothill and canyon areas of the Santa Susana Mountains. In addition, in some portions of the valley, orchards, groves, vineyards, and other crops were being cultivated, primarily with water from the Sylmar Basin.

Since that time, urban development, in the form of residential and industrial

construction, freeway and road development, dams and appurtenant facilities, and concrete-lined drainage systems, has extensively altered the biological character of the area. Cut-and-fill, clearing, and impounding operations have produced large barren spaces, patches of pioneering vegetation, marshy spots, and large artificial ponds; ornamental shrubs and trees have been planted at various locations. The establishment of this variety of new, foreign habitat, in conjunction with the elimination of a greater portion of the natural habitat, has resulted in a biotic community bearing only a slight resemblance to the original.

In general, the vegetation is a mosaic of four major types: coastal sage scrub, secondary successional pioneers, freshwater marsh, and ornamental plantings.

The native vegetation remaining is typical of many areas of Southern California. An examination of the study area failed to find that any of the rare and endangered species* last known to occur in the area are now at the site where connection 3 (Figures 14 and 15) would be built. A search in and around the spreading grounds proposed for use also failed to reveal these species.

The fauna of the area is generally impoverished, as could be expected of an area that has undergone extensive alteration and is subject to constant human disturbance. Species diversity is low and, with the exception of a few rodents and water birds, no species is especially abundant. In the surrounding mountains are some deer and other large mammals. A few have been known to come down into the populated areas when food and water are scarce.

No unique ecological relationship appears to be operating in the study area.

No petroleum-producing well is known to be operating in the San Fernando Valley. Sand and gravel production, on the other hand, is widespread throughout the northeastern part of the valley.

Typical of the valley are many noise-creating sources that tend to fall under the main categories of transportation (including aircraft) and residential. Five freeways crisscross the valley, generating much of the ambient noise in the general vicinity. The Van Nuys, Burbank-Glendale-Pasadena and San Fernando Airports are also major sources of noise.

Environmental Effects

Implementation of the theoretical model could have the following environmental effects:

- Air. Objectionable odors could be created if water is ponded for long periods during the summer when algae growth is more apt to take place. During construction of facilities required for storing and recapturing the SWP water, air pollution could be expected from the exhausts of heavy equipment.

- Water. The alteration of the gradient of ground water and a rise in water levels would take place while the SWP ground water was in storage. Also, spreading large amounts of water could mean possible exposure to water-related hazards, such as attraction of children and pets to spreading grounds during spreading operations.

- Water Quality. Recharging the basin with SWP water (average TDS concentration of less than 250 mg/l) would improve the quality of the existing ground water (400 to 500 mg/l, with pockets of even

*Chorizanthe leptoceras, Chlorizanthe parryi var fernandini, and Berberis nevinii

poorer quality). Conversely, this would also result in SWP ground water of poorer quality than the SWP water delivered on the surface.

If excessively large amounts of SWP water were stored too quickly, the ground water table could be raised high enough to inundate completed sanitary landfills, causing local water quality problems.

Rising water levels would also tend to prevent or slow the poorer quality water in the fringe areas from moving into the main body of the basin.

- Plant Life. Increase of vegetative growth would be expected along the perimeter of the spreading grounds.

- Animal Life. A probable increase of water-oriented birds during spreading operations could take place. The presence of water in the spreading grounds could also add to the propagation of mosquitoes and midges.

  Year-round ponding of water in the spreading grounds, if possible, would generate a potential for development of recreational areas; both the City of Los Angeles Department of Recreation and Parks and the San Fernando Valley Audubon Society have expressed interest toward this end. However, the management plan for the theoretical model does not call for year-round spreading.

- Noise. Some increase in noise level during construction of the facilities required for storage and recapture of the SWP water could be expected.

- Seismic. During the 1971 San Fernando earthquake, the areas that suffered the greatest damage were, with few exceptions, underlain by a varying thickness of Recent alluvial deposits. The damage occurred because the earthquake motions were substantially modified as they traveled from bedrock through the alluvial material.

  To develop ground-motion predictions for the time when SWP water is in storage, all the physical characteristics of the alluvium in the basin as they relate to the transmission of seismic waves will have to be studied. Although the presence of ground water is only one of the numerous parameters that affect the motion at a particular site, an accurate prediction of various modes of ground failure must take into consideration the depth to water. Water levels, on a basinwide average, are now about 91 metres (300 feet) below ground level. The storage of 394.7 cubic hectometres (320,000 acre-

LOPEZ DEBRIS BASIN looking southwest toward the spreading grounds that would be used with all five alternative routes described in the text.

feet) of SWP water is expected to raise water levels approximately 12 metres (40 feet).

However, it should be noted that most of the severe ground displacement that took place during the earthquake was the result of the interaction of soft, alluvial fan material and near-surface ground water. Investigations have indicated that ground displacement under future seismic conditions can be expected to remain confined to displacement zones that developed during the San Fernando earthquake. Even though the storage of SWP water in the San Fernando Ground Water Basin could, in effect, create a hazard by making more water available to the upper soil layers during an earthquake, it is not likely that water levels will be raised high enough to increase the potential for failure.

Nonetheless, because the structural characteristics of soil in the San Fernando Valley generally tend to be poor, the problem of earthquake damage related to the apparent amplification of seismic motions should be a major concern.

Conversely, rising water levels in the San Fernando Basin are not expected to affect the natural occurrence of earthquakes in or around the basin, even though the historic record is far too short to predict this accurately.

All seismic events that took place between 1933 and 1974, a period during which water levels varied dramatically, were plotted and compared with the recorded ground water levels in three representative wells in the basin. From 1931 to 1944, ground water levels in the basin rose to an all-time recorded high. Then, from 1946 to 1968, levels dropped by more than 30.5 metres (100 feet) and have subsequently remained relatively stable. The management plan for the theoretical model is not expected to induce such a major change in ground water levels.

During 1931 to 1974, 363 seismic events of less than 3.0 on the Richter scale, three of 3.0 to 4.0, and one major earthquake of 7.8 were recorded in the valley, but these do not appear to be correlated with changes in water levels.

- <u>Traffic.</u> During construction of storage and recapture facilities, construction equipment could be expected to create a small amount of additional traffic. Some of the alternative routes being considered for conveying water to the spreading grounds for storage would require construction along existing roadways thus interfering with the normal flow of traffic.

- <u>Population.</u> By increasing the dependable yield of the SWP, the San Fernando program would supply a new increment of water to the SWP service areas. This new water could affect growth by supplying water for municipal, industrial, and agricultural expansion. However, the specific effect of such a program is not known at this time.

- <u>Health and Safety.</u> Providing a reservoir of stored water that could be extracted and used by the overlying population in time of emergency would reduce the risks to health and safety that could be created by a shortage of water.

  An excessively high water table could cause property damage in the basin.

- <u>Energy.</u> A net energy use of 27 040 million megajoules (25,620 billion British thermal units, or BTUs) was calculated for

TABLE 16
ENERGY BALANCE SHEET
AT PRIMARY LEVEL

Component	Combination 1 Energy costs	Combination 1 Energy benefits	Combination 2 Energy costs	Combination 2 Energy benefits
	In million megajoules*			
SWP pumping	25 230	--	25 070	--
Distribution/Storage				
Construction	50	--	10	--
OM&R	270	--	790	--
Reduced ground water pumping	--	880	--	2 830
Recapture	4 040	--	4 040	--
Reduced pumping lift	--	1 670	--	1 560
Totals	29 590	2 550	29 910	4 390
Net energy cost	27 040		25 520	
	In billion BTUs*			
SWP pumping	23,890	--	23,740	--
Distribution/Storage				
Construction	50	--	10	--
OM&R	260	--	750	--
Reduced ground water pumping	--	830	--	2,680
Recapture	3,830	--	3,830	--
Reduced pumping lift	--	1,580	--	1,480
Totals	28,030	2,410	28,330	4,160
Net energy cost	25,620		24,170	

*One BTU = 0.0010559 megajoule

combination 1 and 25 520 million megajoules (24,170 billion BTUs) for combination 2. Table 16 is the energy balance sheet for the theoretical model under combinations 1 and 2 using the schedule given in Table 6. For the recapture portion of both combinations, the assumption was that option 1 would be used.

An energy balance sheet is similar to a financial balance sheet. "Energy costs" are the energy units used or lost as the result of the ground water storage. "Energy benefits" are the energy units generated or saved by the storage. All energy quantities are calculated at the primary level. This means a determination is made of the energy content of the total natural resources that must be used to produce the amount of energy needed at the level of use. To do this for electrical pumping requires tracing the electrical energy back through the transmission and generation stages and determining the energy losses and the subsidiary energy required for these processes. For a fossil-fueled plant, the fuel is similarly traced back through the mining, processing, and transportation stages to find all the hidden energies necessary to make the fuel available for power plant uses. To calculate primary energy for construction and operation, maintenance, and

replacement, similar detailed analyses are made.

Energy at the primary level has been calculated in BTUs. Because of the general conversion to the metric system, measurements are reported in megajoules. This allows the primary energy figures to be easily differentiated from the use level figures (expressed in kilowatthours--kWh) given elsewhere in the report.

In Table 16, the component "SWP pumping" is defined as the energy required by the SWP to pump the additional 790 cubic hectometres (640,000 acre-feet) of water for storage from the Sacramento-San Joaquin Delta to Castaic Lake. Under "distribution/storage", the component "construction" is the primary level energy inherent in the facilities that must be built to connect the MWD distribution system with the spreading grounds. The component "OM&R" is the energy required for: (1) treatment at Joseph Jensen Filtration Plant for indirect storage and (2) spreading at the spreading grounds for direct storage. The component "reduced ground water pumping" is the energy saved by the cities because they do not have to pump an amount of ground water equal to that which is stored indirectly. "Recapture" is the energy required for the pumps to recapture the 740 cubic hectometres (600,000 acre-feet)* of SWP ground water. "Reduced pumping lift" is the energy saved by the cities as the result of the higher water levels.

One frame of reference in evaluating the magnitude of these energy quantities is to compare the "net energy costs" of combinations 1 and 2 to the present "net energy costs" of delivering surface water to this same geographical area. When this is done, the net energy cost of combination 1 can be shown to be 8 percent greater and that of combination 2, 2 percent greater.

It should be appreciated that, if the percentage of water stored indirectly (as opposed to spreading) is increased beyond that of combination 2, the relative net energy cost will decrease until it becomes less than existing deliveries. That is, the energy saved as a result of the reduced pumping lift will become greater than the energy used in recapture.

Mitigation Measures

Controls written into the construction specifications would minimize noise, air pollution, and traffic congestion during construction work.

The spreading grounds to be used are owned and operated by LACFCD and the City of Los Angeles, each of which is using control measures to cope with mosquitoes, midges, weeds, and the attractive nuisance of the grounds. Mosquitoes and midges are controlled by limiting ponding to a length of time which is shorter than that required for eggs to develop into adult insects; this can be as short as 8-10 days in summer. The method used consists of filling alternate basins and completing percolation within a week to 10 days, then letting the basins dry for approximately two weeks.

LACFCD controls vegetative growth by periodically mowing it and also by occasionally applying weedicides. The City of Los Angeles controls weeds at its spreading grounds by disking and scraping the top of the soil.

Adequate fencing is maintained at the spreading grounds to aid in keeping out children and pets that might be attracted to the water.

*49.4 cubic hectometres (40,000 acre-feet) remain in storage.

The management plan for the theoretical model calls for establishment of an operating committee, which would be responsible for: (1) testing each phase of operation ahead of time on the City of Los Angeles computer model of the basin to evaluate the volume of water that would be stored or pumped, to determine appropriate pumping patterns for controlling water levels and rising water, and to predict changes in water quality resulting from the operations; (2) selecting and monitoring key wells to ascertain water levels to prevent property damage from a high ground water table and to prevent deterioration of water quality in the basin resulting from interaction of the ground water table and sanitary landfills; and (3) stopping spreading operations when the operating committee's analysis of the data from the computer model and the key wells indicates the possibility of damage to property from increase in water levels. This is not expected to be a problem because the operating schedule shown in Table 6 has been tested on the computer model of the basin and showed no damage from high water levels, interaction with sanitary landfills, or water quality deterioration.

To ensure that rising water levels do not contribute to increased damage should an earthquake occur while SWP water is in the ground, water levels could be monitored to prevent soft and loose soils (with low strength) from becoming overly saturated with SWP water.

If the San Fernando Basin were used as a permanent additional SWP conservation facility for storing SWP water, the following action would be taken to reduce the net energy required:

1. Store as large a percentage of the water by the indirect method as reasonable; and

2. Retain the water in the San Fernando Basin as long as reasonable (i.e., until needed to meet water requests) and replenish after a recapture period.

Compatibility with Existing Zoning

The management plan for the theoretical model would use existing spreading grounds, wells, and related facilities. Construction required to permit spreading and recapturing of SWP water would be confined to land areas already set aside for pipelines, flood control channels, and well fields. Existing land use would therefore not be changed.

Determination

With the above mitigation measures in operation, the impacts defined under environmental effects could not have a significant adverse effect on the environment.

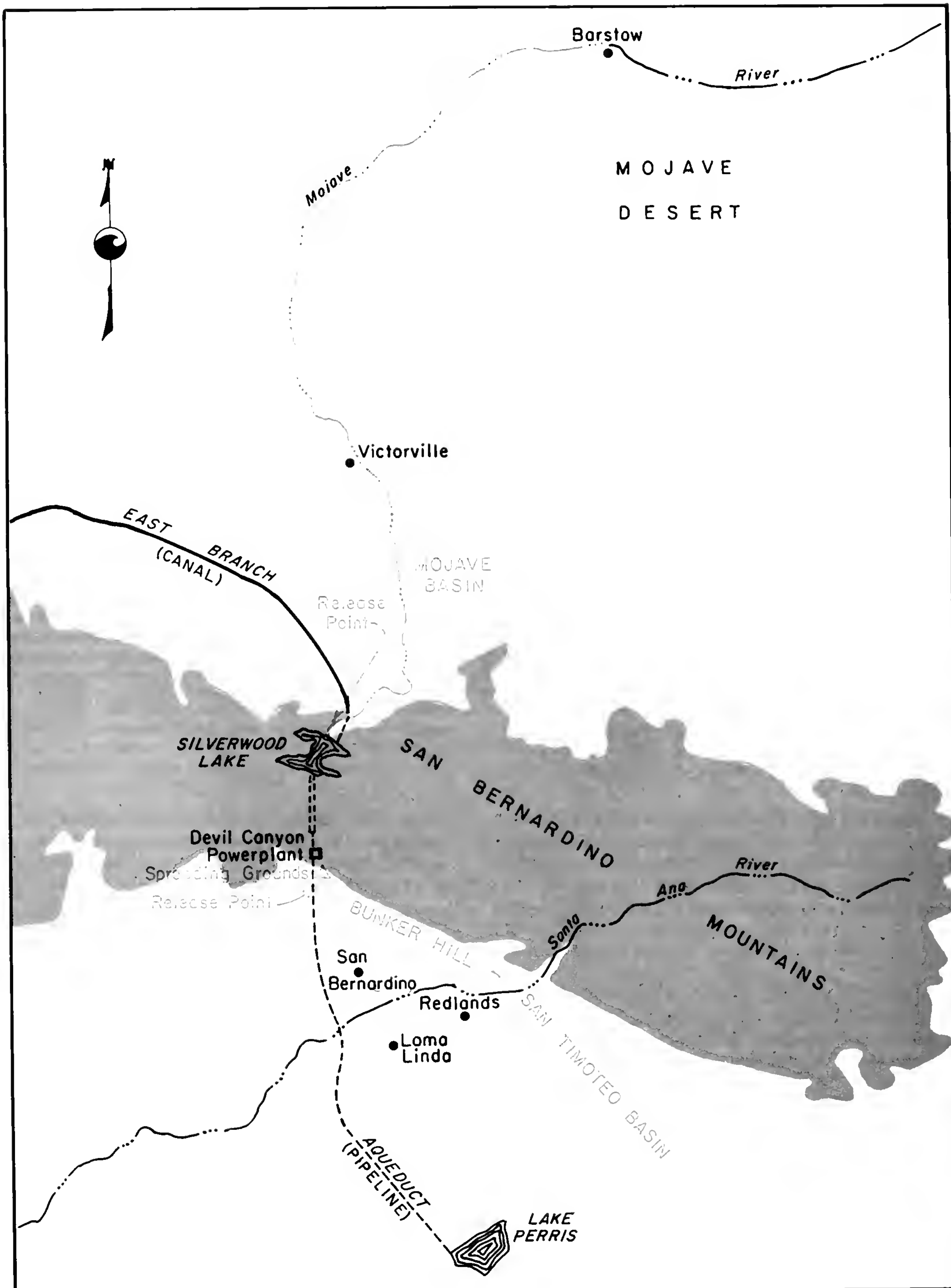

Figure 16 - LOCATION OF DEMONSTRATION PROJECTS

DEPARTMENT OF WATER RESOURCES, SOUTHERN DISTRICT, 1978

EPILOGUE: DEMONSTRATION PROJECTS

As the study of the theoretical model developed, the Department of Water Resources realized that there were a number of economic, legal, and institutional problems which needed to be resolved. The best way of doing this appeared to be through operation of a demonstration project that would serve as a prototype for the actual ground water storage program.

Heavy storms in 1978 produced record quantities of water in many California watersheds. This water offered the opportunity to demonstrate the practicality of a ground water storage program. Therefore, two ground water basins in Southern California were selected for demonstration projects.

The objectives of the demonstration projects are to:

1. *Determine the effectiveness of scheduling techniques for storing and recapturing water for the SWP;*

2. *Confirm cost factors associated with a ground water storage facility;*

3. *Evaluate methods of charging and crediting costs and cash flow effects;*

4. *Identify unforeseen problems; and*

5. *Provide actual experience in administering a ground water storage program in conjunction with the SWP.*

The two basins selected are the Mojave and Bunker Hill-San Timoteo Ground Water Basins (Figure 16) in San Bernardino County. Details of the projects were worked out with the local agencies involved--Mojave Water Agency and San Bernardino Valley Municipal Water District (both SWP water supply contractors) and San Bernardino County Flood Control District and the City of San Bernardino. Actual storage began May 9, 1978.

The Mojave Ground Water Basin follows the Mojave River north from the San Bernardino Mountains. The basin is in the south central portion of the Mojave Desert. The area is largely undeveloped, but a number of towns and communities lie along the river; the largest of these are Barstow with a 1975 population of 22,300 and

SWP WATER ON ITS WAY TO BECOMING SWP GROUND WATER. *Release of SWP water for storage in Bunker Hill-San Timoteo Ground Water Basin came on July 7, 1978. Water will be stored and pumped later by San Bernardino Valley Municipal Water District as part of its annual entitlement.*

MOJAVE RIVER before (photo above) and after (photo below) the release of SWP surface water. A total of 28 cubic hectometres (22,500 acre-feet) was released to percolate to the ground water basin for storage. This is part of a demonstration project begun in May of 1978 by the Department of Water Resources and the Mojave Water Agency.

Victorville with 14,000. The area is served by the Mojave Water Agency.

The Bunker Hill-San Timoteo Ground Water Basin is in the southwestern portion of San Bernardino County, on the southside of the San Bernardino Mountains. The East Branch of the California Aqueduct extends southeast across the basin from Devil Canyon Powerplant toward Lake Perris. The Santa Ana River flows southwest across the basin. The area is primarily urban with some irrigated agriculture remaining. The largest cities are San Bernardino, Redlands, and Loma Linda. The basin lies within the service area of the San Bernardino Valley Municipal Water District.

Under terms of the agreement covering the demonstration projects, floodflows from the Kern River in the San Joaquin Valley were transported via the California Aqueduct to Silverwood Lake, which is in the San Bernardino Mountains. The water was then released from the lake to the Mojave River for recharging the Mojave Ground Water Basin. The total amount stored is 28 cubic hectometres (22,500 acre-feet).

Over the next four years, the Mojave Water Agency will purchase this water and be able to pump and use it instead of an equal amount of SWP water delivered on the surface.

On July 7, storage for the second demonstration project began; this one is being conducted by the San Bernardino Valley Municipal Water District. Under this project, a maximum of 61.7 cubic hectometres (50,000 acre-feet) of SWP water will be stored in Bunker Hill-San Timoteo Ground Water Basin. Of this, 28 cubic hectometres (22,500 acre-feet) is the SWP surface-delivered water that Mojave Water Agency will not be receiving.

As needed for SWP operations, San Bernardino Valley Municipal Water District will be directed to pump the stored water instead of taking delivery of an equal amount of SWP surface-delivered water. This recapture is to take place within 15 years of the start of the project.

The allocation of costs will be virtually the same as that developed for the theoretical model in the San Fernando Basin.

ACKNOWLEDGEMENTS FOR PHOTOGRAPHS

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